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ABSTRACT

Part 2 of a three-part volume for research and development systems researchers, this report attempts to apply the contextual analysis framework of research, development, and innovation (RD & I) activities presented in Part 1. The authors make a detailed analysis of RD & I activities in the sectors of education, civilian aviation, health, and criminal justice. RD & I in each sector is analyzed in terms of each of the contextual features of RD & I identified in Part 1. The important features of RD & I examined are environmental influences; historical development; institutional base; goals, policies, and strategies; administrative processes; personnel base; funding; information flow; and innovations. The functions of RD & I examined in each sector are need identification, generation or research, development, production, marketing or dissemination, acquisition, implementation and utilization, support services, and evaluation research. A final chapter presents in table form a comparative summary of the contextual analyses of all four sectors. The table is intended to provide insight into the similarities and differences in RD & I across sectors. (Author/JM)

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CENTER FOR THE INTERDISCIPLINARY STUDY OF SCIENCE AND TECHNOLOGY

Northwestern University
Evanston, Illinois

Research, Development And Innovation: Contextual Analysis

Part Two

December 1977

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Michael Radnor
Harriet Spivak
Durward Hofler

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RESEARCH, DEVELOPMENT AND INNOVATION:

CONTEXTUAL ANALYSIS

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CHAPTER THREE

THE R/D&I CONTEXT IN THE EDUCATION SECTOR

A volume-length analysis of the educational R/D&I context is in preparation and will be on file at the National Institute of Education (NIE). In the chapter presented here, we summarize key points made in the lengthier analysis. Specifically, each of the 19 contextual features will be reviewed below to describe the context for analysis of the educational R/D&I system.

It should be noted that much of this analysis is based on impressionistic sources -- impressions derived from immersion in the literature relevant to analysis of key features of the educational R/D&I system and impressions derived from the analysts' personal experiences and familiarity with the educational R/D&I and operating systems. The lengthier analysis provides extensive citations and other documentation, as well as some discussion of key points in need of empirical verification.

I. ENVIRONMENTS OF THE R/D&I SYSTEM

1. Vulnerability

A. A Public Base

Of all the sectors we have considered in our comparative analysis, education is clearly the most vulnerable -- the most open to (and subject to) social and political influence.(125) As public service institutions supported by public funds and administered and regulated by public agencies, schools affect all subgroups of the population (as citizens and taxpayers). Since the proportion of local funds spent on public education tends to be quite high, schools tend to be particularly salient to taxpayers. For those taxpayers who are also parents of school-age children, the level of concern about school functioning tends to be even higher -- American society has been characterized by tremendously high expectations for schooling. The business community, too, has been expressing great concern about school functioning, bemoaning the poor quality of work force preparation for the world of work.(24)

B. Goals

Education, by its nature, also has more diffuse goals than other sectors -- goals that are more subject to value-laden judgments, misinterpretations, and controversy; goals that are harder to specify, less measurable, and harder to use as performance standards against which to judge system performance.(125) In comparison to other sectors, then, the functioning and effectiveness of educators, educational R/D&I personnel and the educational system as a whole are more likely to be subject to scrutiny and debate.

C. Legitimacy Problems

Contributing to the vulnerability of the education sector is the educator's legitimacy problems in claiming specialized expertise and professional status. Compared to scientists, engineers, doctors, or lawyers, the specialized training needed to function as a teacher or principal does not seem particularly awesome. From their own personal experience (as well as close observation of the experience of others), the public has more familiarity with what the educator does (as compared to knowing what an engineer or a lawyer does). Therefore, particularly for the better educated parent, there is far less of a gap in expertise between the general public and educators than between the public and professionals in fields with strong knowledge or technology bases. Similarly, compared to fields with well developed knowledge and technology bases and highly specialized development activities (e.g.: engineering), there does not appear to be much of a gap in expertise between the R&D personnel who develop many of the learning materials on the market and the teachers who develop their own materials, or even parents who peruse the materials used by their children.

D. The Nature of Educational Innovations

Adding to the vulnerability of educational R/D&I is the nature of educational innovations, as compared to the more technolegial outputs of R/D&I systems in other sectors, where R&D products are easily packaged and installed; where use rarely conflicts with the values, attitudes, and sensitivities of operating system personnel; and where products can be expected to behave reliably in accordance with their performance specifications (as long as they are used properly). Educational innovations, in contrast, tend to involve "people change" -- e.g.: creation of new capabilities or organizational strategies or instructional approaches. They are therefore more likely to be resisted -- by the people who make adoption decisions and by those who must implement them. As "people change" products, there is far greater reactiveness between product and users (both school personnel as intermediate users and students as end users). Therefore, implementation is more difficult, and effects are far less predictable. Even when effective, educational innovations are harder to prove effective -- their effects are harder to demonstrate objectively and are therefore more subject to dispute. Further, there may be controversy over the *desirability* of intended effects.(48, 59, 61, 74)

E. Weakness of the Scientific and Technological Base

The weakness of the scientific and technological base of education and educational R/D&I is at the crux of much of the environmental vulnerability of this sector. Though it shares much common ground with the social sciences and other applied social science fields as well, education is particularly vulnerable here. For example, we may note the following:

1. The development of a knowledge base in the social sciences and applied fields like education involves research on humans rather than non-humans, and this raises numerous value questions about what should be studied and how;(48, 50) the ethics of research; safeguarding the rights of those studied; etc.

2. It also entails greater uncertainties in the research situation since the humans studied (unlike rocks or molecules) have and exercise free will and are thus "reactive" to innovations.(48, 50) Therefore, reliability issues become particularly troublesome.

3. There is also a greater likelihood of bias creeping in through the researcher's own biases or the quality of the interaction between researcher and subject.

4. Experimental designs calling for randomization or various kinds of controls are also less feasible with humans, especially in field settings as opposed to laboratory research.(53)

2. Governance Structures

A. The Value Problem

The value-laden nature of education and educational R/D&I is particularly problematic, given the governance structure of education and educational R/D&I. School systems are legally controlled by agencies in their environment. Both school systems and educational R/D&I institutions are largely dependent on these agencies for their funding. Legal control over the operating system is vested in lay boards of education, elected (or appointed by elected officials) in each of the approximately 17,000 school districts across the country. This lay control, its relationship to political processes, and its extreme decentralization are factors of some consequence. Although professional (i.e.; the Superintendent) dominance of lay boards is the rule, there are frequent exceptions. Especially in controversial areas (e.g.; busing, sex education), unless the Superintendent is a person with strong leadership abilities and a clear vision of what he or she wants, community pressures can have a major impact on school functioning.

B. Formal Governance Structures

In terms of formal governance structures, the educational system in the U.S. is characterized by extreme decentralization. In contrast to centralized systems (as in France, for example) which have centrally prescribed courses, textbooks and learning materials, centrally developed examination systems, and extensive monitoring of school operations by school inspectors, each of the thousands of local school districts in this country is largely autonomous. Though legal authority to regulate schooling is vested in the governments of the states, few if any states actively monitor school functioning, and on the whole, local districts are highly autonomous from state and federal authorities. In operational terms, decentralization tends to go considerably beyond the decision making autonomy of the districts. Within each district there is considerably autonomy at the the local school level, with the principals (and also teachers) having a great deal of leeway in determining what happens in their classrooms. This degree of autonomy down to the school and classroom level is a factor of considerable importance in explaining why innovations that are formally adopted by a school district are so often not implemented in practice, or are so transformed during implementation that they amount to little more than "the same old thing".(51, 119)

C. Funding Control

In the case of the educational R/D&I system, the ultimate control over decisions affecting funding -- and therefore R/D&I functioning -- is the Congress. Given the history of Congress's lack of confidence in the ability of educational R/D&I to provide a reasonable return on the taxpayer's investment, this has meant almost constant troubles for the R/D&I system.

3. Economic Forces

Economic forces in the environment of the educational operating and R/D&I systems have been felt particularly severely in recent years. On the state and local level, school financing has become one of the paramount issues of the day. We find increasing numbers of cases of states and local communities struggling over equitable financing formulas; states cutting assistance to local districts as they struggle with their own financial difficulties; and voters in local districts defeating school budgets and bond issues in an effort to stave off further increases in local taxes. Economic recession has also meant a shortage of slack resources in the private sector to invest in high risk/low return R/D&I activities.

4. Summary: Weak Supports and Assertive Demands

In all, we can characterize the environment of the education sector as one that tends to be weak in supports for the system and assertive in demands about what can or cannot be done, should or should not be done. R&D in education tends to lack prestige or legitimacy -- or even a strong demand for its products or its very existence. This seems apparent whether we focus on the attitudes of researchers and scholars in the disciplines, educational practitioners, laymen, Congressmen, or even the education research and R&D communities. The system appears to have developed no strong constituency of its own and is buffeted by the initiatives of various other constituencies able to articulate demands reflecting broad social, cultural, and political movements in the society as a whole (e.g.: integration, ethnic consciousness, feminism).

The environment of the education sector affects virtually every feature of the R/D&I system -- the definition of goals, needs, and strategies; the level and quality of personnel, funding, and other resources that flow into the system; and the functioning of the system itself (what research problems or R&D topics are attended to; the manner in which problems are defined; the amount that must be invested in early phases of R&D activity because of the weakness of the knowledge base and the transforms between stages; the controls that are exercised over research to protect human subjects; the credibility of the research and R&D effort with different constituencies (as evidenced for instance in the numerous examples of the black community's unwillingness to participate in survey research in the late '60s). No other sector we have considered in our comparative analysis is confronted with such serious environmental pressures. None is as dependent on environmental institutions for its support. And none is dependent on an environment so inimical to its chances for development and maturation.

II. HISTORICAL DEVELOPMENT

1. A Newly Institutionalized System

The development of instructional strategies and learning materials has been going on as long as there have been teachers and students, and we can find examples of institutionalized educational research in this country over a relatively long historical period. Nonetheless, we must note that institutionalized R/D&I in education is only a little more than a decade old. That is to say, new to the field of education is institutionalized, linked R/D&I as an interrelated set of processes revolving around the development function and carried out by specialized personnel under specially designed organizational arrangements. While the newness of a system may not be significant in itself (few institutionalized R/D&I systems in any sectors are more than a few decades old), it is a factor of some consequence when compared to the centuries of history and tradition that characterize the operating system of educational institutions. The operating system served by educational R&D is old in history and heavily laden with traditions, norms, and values that run counter to the acceptance of outputs of external R&D.

Thus, the educational R/D&I system has not yet established its legitimacy. It competes against traditional approaches to producing knowledge, programs, and products for educational institutions -- and it uses scarce resources. Its methods and outputs have not yet proven their superiority to traditional methods and outputs. In many cases, the products of educational R/D&I appear to be clearly inferior to conventionally developed products.

There would seem to be abundant evidence that the system's present state of maturation places it within the boundaries of the introductory stage of historical development. It is a relatively young system. As we will discuss later in this analysis, many functional specialties of mature R/D&I systems are almost totally absent in education. Those that do exist either emerged as areas of specialization after the R/D&I system was institutionalized in the mid-'60s, or were wholly transformed by the demands of that system. The functional specialties provided in the specialized R/D&I institutions exist alongside of -- and compete with -- similar activities carried out in the other, older parts of the education sector. The system has been characterized by a high level of instability in both macro and micro level structures. Neither its funding nor its personnel bases have been adequate to the demands of system functioning or appropriate to the quantity and quality of outputs expected by the system's sponsors. The field's knowledge and technology base is inadequately developed. R/D&I functioning in education has been hampered by amorphousness of standards; ambiguities in defining work roles and requisite skills and compentencies; and inadequacies in information flow. The knowledge producing and knowledge utilizing components of the system are poorly integrated. System outputs have been generally low in quality.

2. Critical Events

A. 1954-1972

A number of critical events have shaped the system, brought it to its current point of development, and continue to be felt as constraints on system functioning. The most significant events in the birth of institutionalized R/D&I in education are: (1) the emergence of the federal government as the primary sponsor of educational R/D&I in the mid-'50s; and (2) the enormous expansion of federal funding programs in the '60s. The most important legislation has been: (1) the Cooperative Research Act (1954 and subsequent amendments); (2) the National Defense Education Act (1958); and (3) the Elementary and Secondary Education Act (1964).(39, 93) Through these pieces of legislation, the federal government created major new funding programs and also created a network of new Office of Education (OE) funded institutions which were separate from the existing bases of R/D&I activity and external to the operating system.

The new network of R/D&I institutions external to the operating system included: university-based R&D centers, regional laboratories established in the form of quasi-public corporations located in non-university settings; ERIC clearinghouses; ESEA Title III demonstration centers; and various kinds of materials centers. Although both the laboratories and centers were expected to carry out activities covering the full range of R/D&I activities, the academic locations of the centers suggested that they would be particularly well suited to conduct research and prototype development; the laboratories, as institutions apart from the research subculture of the universities, were expected to be in a better position to attract full-time development-oriented personnel, and were therefore expected by many to carry out much of the system's R/D&I activity oriented toward full development, testing, and packaging of prototypes into usable products and program packages. As it turned out, especially in the initial years of functioning of the new network of institutions, there was only a limited amount of this functional specialization, and (with some exceptions) the laboratories and centers operated independent of one another's work, each attempting to carry out the full range of research, development, and dissemination work connected with its products. Adding to this picture of minimal integration among system institutions, the dissemination-oriented institutions in the system (e.g., the ERIC clearinghouses, ESEA Title III centers, materials centers, etc.) tended to define their agendas and carry out their activities in ways that were for the most part unrelated to the work of the laboratories and centers. High quality outputs were expected to materialize quickly from this new network of institutions and to have immediate and widespread impact on school system programs and practices. When this goal was not achieved within only a few years, Congressional disillusionment set in; large numbers of laboratories and centers lost their funding and went out of existence; and educational R/D&I appeared to be in deep trouble. (There were 13 R&D centers and 20 laboratories by 1967; by 1972, only 23 of these 33 remained; by 1975, only 17 of the 33.)(93)

The educational R/D&I system, as that system is generally conceived today, encompasses an institutional base considerably broader than the labs and centers and other specialized R/D&I institutions newly created by the Office of Education in the '60s. It includes work carried out in academic institutions, in the private sector, in federal, state, and local agencies, etc.(88) And recent analyses of the federal government's sponsorship of educational R/D&I activities underscore how many different federal agencies and programs fund educational R/D&I efforts.(76, 77, 78, 102) Future histories of educational R/D&I, and especially federal sponsorship of educational R/D&I activity, are likely to meet the as yet unmet need for analysis of significant patterns in R/D&I functioning in this broader set of R/D&I performers and sponsors. At present, however, based on available published sources, there is relatively little that we can say about how this broader system fared in the '60s, and early '70s. Still, whatever picture of educational R/D&I in these other settings may appear in some future histories, the visibility of OE funding for educational R/D&I in these years (in contrast to funding for such work from other agencies), and the close association in the minds of many (e.g.: Congressional critics, practitioner critics, etc.) between the labs and centers on the one hand and the sum total of educational R&D on the other suggest that the successes, failures, and fate of the labs and centers in these early years might affect the broader educational R/D&I system and its sponsorship for some time to come regardless of whatever may be learned subsequently about the broader system, its functioning, and its outputs.

The ups and downs in Administration and Congressional support for educational R/D&I have had a critical impact on the system since there are so few other bases of R/D&I funding. The R/D&I funding that comes from private foundations is small in comparison to the sums invested by federal agencies. (In FY 1968, private foundations provided approximately $7 million of a $192 million documented minimum base of financial support for educational R&D.(103) For FY 1975, private foundations were estimated to provide $57 million to $65 million of a total of $605 to $673 million of educational R/D&I funding in this country.(102)) Furthermore, potential bases of funding -- the education industries, entrepreneurial firms, state and local educational agencies -- have until recently failed to allocate substantial resources to R/D&I activities, and even now the amounts that come from these other potential bases of funding are relatively small (somewhere between $35 and $85 million annually).(93)

B. 1972 - NIE

The educational R/D&I system was given a brief reprieve from what appeared to be an inevitable premature death. In 1972, the National Institute of Education was created, and control over many of th[illegible]E-sponsored R&D programs were transferred to this agency (especially those programs like the labs and centers program which had come under Congressional attack). NIE was given a legislative mandate "to build an effective R&D system." Implicitly, it appeared that NIE was to become the lead agency for the federal government sponsorship of R/D&I in education and that its fate would become synonymous with educational R/D&I -- as had the OE-sponsored labs and centers program in the '60s.

Unfortunately, the Institute itself encountered almost immediate problems of its own, the most serious of which were its appropriations struggles with the Congress. In 1974, federal funding for NIE (obligations) was cut, from $106.8 million in FY 1973 to $75.7 million in FY 1974, a figure lower than equivalent OE educational R/D&I program allocations had been since 1965. The zero funding recommended by the Senate threatened the very existence of NIE and implicitly educational R/D&I in general. Since 1974, NIE's funding status appears to have stabilized (albeit at the rather modest $70+ million level). Still, the key barometer of this relationship for the near-term and long-term future is likely to be the extent to which the Agency succeeds (if indeed it does at all) in substantially increasing its appropriation.

NIE has been in existence for only a few years, and efforts to contrast NIE policies and orientations with previous federal educational R/D&I policies are hazardous -- given how little evidence is available about federal sponsorship of educational R/D&I activity outside of OE and federal funding targetted at institutions other than the OE-created labs and centers. Still, our observations and impressions of federally-sponsored educational R/D&I functioning in the pre-NIE decade and subsequent period suggest the following strong points in NIE's favor that seem to warrant mention.

In contrast to OE policies in the '60s that focused so much attention on the labs and centers, NIE policies and programs appear to have restored greater balance to overall system development. By supporting both the traditional bases of R/D&I activity (academic institutions, private sector organizations and the operating system) as well as the new institutions that emerged in the '60s, NIE has been supporting sources of educational innovation that are both internal and external to the user system. NIE program funding emphasizes not only research and development activity (as did OE in its funding of the labs and centers), but also dissemination, delivery, and building internal user system capabilities for need identification, development, implementation, and utilization. State education agencies have been taking increasingly active leadership roles in dissemination and in providing technical assistance to school systems. NIE has also been emphasizing the role of the state education agencies as key sources of leadership in these areas.

But NIE has not as yet developed a strong constituency within the research and R&D communities and among the powerful education interests and lobbies. Consequently, educational R/D&I continues to be buffeted by environmental forces, with little prestige or clout of its own to buttress it against environmental pressures that impair system functioning. Educational R/D&I has been likened to a tree that is planted and then torn out by the roots every couple of years to see how it is growing. To understand why this has been so, we must examine the environment of educational R/D&I.

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)

Analysis of the structure of the educational R/D&I system suggests the existence of several parallel subsystems characterized by minimal specialization, considerable redundancy, looped as well as adjacent clusterings of functions, major gaps between functions, and inadequate linkages among subsystems as well as functions. The overall structure is diffuse, much of it lacks formalization, and whatever centralization or coordination might seem to be inherent in the dominant role of the federal government in R/D&I sponsorship is more potential than operational at this time.

The focus of our attention here is on the network of institutions that carry out R/D&I activities per se rather than either the superordinate system that provides resources and contraints and accepts system outputs (i.e.: the federal and to a lesser extent state agencies and private foundations) or the subordinate system of mostly sector-spanning organizations that provide support services (e.g.: data processing service bureaus, equipment suppliers, maintenance firms, etc.).

1. Parallel Subsystems Within the R/D&I System

The structure of the educational R/D&I system is, in reality, a set of three parallel subsystems.

A. Colleges and Universities

One subsystem is made up of various organizational settings located within the colleges and universities -- schools, colleges, and departments of education; educational research bureaus; various academic departments in the social sciences and occasionally other disciplines as well; and university based interdisciplinary research centers and institutes.

B. Quasi-Public and Private Sector Institutions

A second subsystem parallel to the first is made up of the large and proliferating number of quasi-public and private sector institutions currently engaged in educational R/D&I -- the federally funded regional laboratories, R&D centers, ERIC clearinghouses, materials centers, etc.; non-profit and for-profit research corporations geared to the federal grants and contracts economy; organizations from private industry that have been making tentative forays into educational R/D&I; and others such as publishers and audiovisual firms that have strong, established footholds in the education sector.

C. SEAs, ISAs, and LEAs

The operating system of State Education Agencies (SEAs), Intermediate Service Agencies (ISAs), and Local Education Agencies (LEAs) are so weakly linked to these other two subsystems, and often so redundant with them in the conduct of R/D&I activities, that we have identified the operating system as a third, parallel stream rather than as the KU target of KP activities in these other two streams.

D. Linkages Within Each Subsystem

Within each of these subsystems there is some interaction of a more or less informal nature -- but far less than one would imagine given the physical proximity of organizational units within the academic setting; or given the operating system's formal governance structure that would lead one to expect to find extensive interaction and monitoring between SEA and LEA personnel; or considering the commonality of interests that would lead one to expect extensive communication among schools or between LEAs and SEAs.

ISAs represent a new development aimed at increasing linkages among school districts, and between school districts and their SEAs. Aside from this one exception (and even here, only some states have created ISAs -- and these tend to be quite new), linkages within each of the three subsystems are incidental and informal rather than institutionalized, permanent, and strong. Consequently, communication and information flow are weak, and knowledge production and utilization are inefficient and far less effective than they might otherwise be. Developments in social science departments tend to have relatively little impact on developments in schools of education. R&D activities in one research corporation have little impact on R&D activities in others. As yet, local innovations in one school district seem to have little impact on practices in other districts.

E. Linkages Between Subsystems

Equally (and perhaps even more) serious are weaknesses in the linkages among these parallel subsystems. The academic community tends to function in relative isolation from both the operating system and the research corporations that dominate R&D activity. Consequently, the research findings produced by the universities have relatively limited impact outside that subsystem. The operating system is linked to publishers and equipment suppliers in the private sector but otherwise generally develops its own programs and materials and tends more often than not to operate as though there were no educational research community, no relevant research findings, and no externally developed R&D products and programs. (9, 51, 54, 57, 139) The general pattern in the regional laboratories and the research corporations is to develop products and programs in relative isolation from either the academic community and its accumulated knowledge base or the user system and its perceived needs and constraints. There are notable exceptions, of course, and some strong collaborative arrangements have been forged in a number of instances (e.g.: Northwest Regional Laboratory in relation to school districts in its region). But on the whole, individual R/D&I institutions and organizational units tend to function in isolation, linked weakly if at all to other institutions or units or their immediate subsystem or other subsystems in the macrostructure.

2. A Linear Model in Theory but not in Practice

A. A Low Degree of Functional Specialization

The linear model that is now in general disrepute but seems to have been a significant influence on much of the early R/D&I thinking in the '60s assumed that a "natural" specialization of functions and a pass-it-on flow of R/D&I activity would emerge in the relationship among these subsystems. The university subsystem seemed inherently suited to research; the non-university corporations seemed designed to meet the needs of programmatic development work; and the operating system was viewed narrowly as the target to receive the outputs researched in the universities and developed in the corporations. Functional specialization was assumed, as were the linkages, two-way interactions, and knowledge feedback flows required for an integrated system. To whatever extent the linear model may be accepted as a reasonable description of R/D&I configurations in any other sector, empirical reality in the education sector reveals a somewhat different picture.

The relatively limited degree of specialization and extensive amount of redundancy that characterize the educational R/D&I system can be seen in the location and clustering of R/D&I functions in the various institutions that make up the system. The greatest amount of specialization occurs at the basic research end of the educational KPU spectrum, with most basic research concentrated in the universities and especially in the academic departments. Some basic research is done in some of the larger, wealthier, and more prestigious corporations (e.g.: Educational Testing Service). But for the most part, basic research is the private preserve of the universities.

Applied research, however, is carried out in one form or another in research institutions or units scattered throughout all the various types of organizational settings in the system -- the universities; the R&D centers and regional laboratories; the research corporations; and even some of the strong SEAs and big-city LEAs that have the resources to carry out policy research as part of their long-range planning and monitoring efforts.

The bulk of federally funded development work is carried out in the regional laboratories and the large research corporations. However, development work in one form or another takes place in virtually all types of organizational settings in all three subsystems. Similarly, dissemination and evaluation contracts are being awarded increasingly to institutions located in only certain segments of the overall structure (dissemination contracts increasingly to SEAs and organizations working with them; evaluation contracts increasingly to the research corporations). Nonetheless, dissemination and evaluation activities, too, are carried out in one form or another throughout the structure, even in organizational units within the superordinate structure of federal and state agencies.

If we consider the implementation and utilization support functions, what little linkage specialization exists to provide user system personnel with technical assistance in building internal capabilities or implementing externally developed R&D products, tends to be located either in new linkage and technical assistance organizations (generally small non-profit corporations) or in the hands of a small group of staffers from a laboratory or R&D organization that is trying to install one of its products. Still, even here, careful analysis uncovers some linkage, technical assistance, and implemantation support activities in the universities, in some of the stronger SEAs, and in LEAs and individual schools well endowed with curriculum specialists and other specialized personnel.

Overall, then, functional specialization among education R&D organizations tends to be somewhat limited, with most of these institutions encompassing several R/D&I functions. The pattern is not only one of limited functional specialization, but also limited specialization in substantive areas of R/D&I activity. Basic researchers tend to become specialists in narrowly defined research areas and subjects of investigation. However, applied researchers, developers, evaluators, disseminators, and implementation support personnel tend to be generalists within their functions -- e.g.: one year evaluating compensatory education programs; the next year examining the effectiveness of alternative dissemination strategies; the next year assessing the quality of ERIC information analysis products, etc. Within a few months time, a single large R/D&I organization within the education sector may respond to RFPs and bid on and be awarded contracts covering the whole range of functional specialties and an array of topical areas; and some of the same personnel may be assigned to work on several of these rather different contracts at the same time. Some of these organizations may also be working on contracts involving R/D&I activities in fields of health, personnel development, social welfare programs, etc. Clearly, this pattern is at considerable variance from a sector like the aviation/aerospace industry where there is highly developed specialization by function, by components (e.g.: airframes, engines, electronics), and even by R&D problem areas (e.g.: wing stress analysis).

B. A High Degree of Functional Clustering

Examination of the clustering of functions within R/D&I institutions reveals, not surprisingly, that basic research is the most specialized of the various functions and the least likely to cluster with any of the others. This is attributable to the nature of the knowledge and technology base of the basic research function; the socialization and training of its personnel; and the values, norms, and mores of the university settings in which it takes place. If we ignore basic research and consider the remaining R/D&I functions, we find several forms of both adjacent and looping clusters.

A significant amount of clustering surrounds the development function -- e.g.: applied research and development; development and dissemination; development and production of support materials for implementation/utilization, and even development/dissemination/implementation clustering. The clustering is the outcome of conscious policy decisions of educational R/D&I managers. A less formalized version of the same kind of clustering (minus dissemination) would be represented by the creative teacher who generates an idea, gathers relevant information, develops it into a teaching strategy and instructional materials, and then uses them in her classroom.

Dissemination and implementation/utilization clustering is becoming increasingly frequent as a result of the knowledge base and personnel base that spans these two functions and as a result of the kinds of organizational arrangements that are being created by explicit and intentional policy initiatives of federal and state agencies (e.g.: training programs for dissemination and utilization specialists; state creation of ISAs to provide dissemination and technical assistance services to school districts; NIE's R&D utilization program; etc.).

Applied research and evaluation were a natural cluster during the first few years of the emergence of the evaluation research function, largely because evaluation personnel were trained as researchers; were interested in conducting research rather than evaluation; were forced into evaluation work by the operation of the laws of personnel supply and demand; and tended more often than not to piggyback research projects onto required evaluation activities. As evaluation has matured and developed an identity, methodology, and personnel base of its own, this basis for the research/evaluation cluster has been less prominent. Still, there are several examples of well-run R&D programs where questions uncovered in the course of product or program evaluations are turned over to research personnel for further investigation oriented toward future development cycles for further product refinement (e.g.: in the development of the Individually Prescribed Instruction Program by the Learning Research and Development Center and by Research for Better Schools).

One of the newest clusterings to appear is a utilization/research cluster that may lead to maturation of a practice-oriented research specialty (as illustrated by work now in progress by the Center for New Schools to document and analyze nine LEA local problem solving projects supported by NIE).

Equally new is a utilization/development/dissemination or utilization/dissemination cluster evident in projects to identify exemplary practices, document and analyze them, use them as the basis for materials development, and disseminate these practices and materials to other potential users. The configuration is changing somewhat as more and more resources are being allocated to building linkages. Initially, this took the form of temporary collaborative arrangements and joint ventures for individual projects, joining together institutions with complementary capabilities or functional specialties. Increasingly the consortia and networks that are being proposed and experimented with are intended to be permanent, formalized interface arrangements providing either horizontal integration (linking similar institutions or organizations) or vertical integration (linking functions and/or subsystems). It will be some time, however, before we can expect to see the effects of these initiatives on the configuration of educational R/D&I institutions.

3. A Final Point: The Place of Large Corporations

One further point should be noted before we leave the topic of the structure of the R/D&I system in education. Several large corporations appear to have particularly strong positions in the grants and contracts economy of the education sector -- e.g.: American Institutes of Research, Rand Corporation, Stanford Research Institute, and Educational Testing Service. In fact, in the period FY 1973 - FY 1975, fewer than 50 organizations received the majority of NIE funding support.(93) Still, the number of R/D&I institutions receiving funds from all sources is substantial and it would seem unwarranted at this time to suggest that certain types of R/D&I in the education sector are dominated by a few large institutions in a pattern resembling the aviation/aerospace industry. However, we will be in a better position to assess this question after the NIE KPU monitoring project provides empirical data about the individual institutions that carry out educational R/D&I activities, important for understanding the emergent configuration of educational R/D&I institutions and for developing appropriate policy initiatives and strategies for macrostructure management.

IV. GOALS, POLICIES, STRATEGIES

1. Weaknesses

Educational R/D&I has been criticized repeatedly for weaknesses in goal setting, priority determination, policy formation, and strategy development.(49, 73, 83, 103, 128) Given OE's and now NIE's status as the dominant sponsors and primary influences on educational R/D&I, it is goal setting in these agencies that must be the focus of our attention.

On the most general level, the goals of federal policy for the system have been reasonably consistent throughout the OE and NIE years. Using the current NIE formulation, these goals have been: to solve educational problems; to improve educational practice; to develop the knowledge and technology base needed for these efforts; and to develop an effective R&D system.

However, when analysis proceeds beyond broad goal statements to specific policies, programs and activities of OE and NIE (and when special note is taken of relative emphases in budget allocations), the picture that emerges is one of marked discontinuity, shifting goals and priorities, and policies and strategies that have not been entirely consistent with some of the system's goals. What has been lacking until recently has been adequate translation of broad goal statements into intermediate goals and objectives specific enough to guide priority determination, policy formation, and strategy development -- and specific enough to serve as benchmarks for measuring system performance.(126) Also lacking have been mechanisms to develop consensus on specific system goals, priorities, policies, and strategies among the various constituencies affected.

2. Historical Patterns: Changing Priorities and Decisionmakers

Historically, there has been a close relationship between the dominant system goals and priorities, on the one hand, and the primary locus of goal-setting, on the other.

A. Stage One: Research Emphasis

In the late '50s and early '60s when the dominant source of funding was the Cooperative Research Act, system priorities were determined largely by the educational research community. The locus of goal-setting was decentralized, scattered among all the various researchers and KP (knowledge production) institutions who submitted field-initiated proposals and the prominent researchers who served on review and advisory panels. In a researcher-dominated context, research was rather naturally emphasized. Development of the field's knowledge base was the goal of the system; funding educational research projects was essentially the strategy; and funds flowed primarily to the universities where educational research personnel was located.(25)

B. Stage Two: Centralization and Short Term Emphases

This pattern changed drastically in the mid-'60s when OE funding emphases shifted from field-initiated research projects to more bureaucratically-defined, mission-oriented, programmatic R&D. The shift was gradual. When the laboratories and centers were first created, each institution defined its own mission based on the areas of specialization of its senior level personnel. Over time, however, with increasing OE use of RFPs and targetted research programs, the locus of goal-setting became highly centralized as it shifted to key OE staff members with some assistance from their advisers, whom they selected from the research and R&D communities.(25)

With the shift to a centralized locus of goal-setting, there was a marked change in goals and emphases. There was less and less concern with the field's knowledge base, and more and more attention to the shorter-range goal of solving immediate problems of the operating system. Those problem areas receiving the largest allocations of funds (e.g.: improving the academic achievement of low-income, minority students)(103) were defined largely by social and political forces external to the education sector -- rather than by the dominant concerns of practitioners at that time, or by the needs of the field's knowledge base, or even by the state of development of the knowledge base to permit effective attack on particular problems. The bulk of resources went to the development function rather than research. The time horizons of the dominant goals were immediate and short-ranged. The emphasis was on developing packageable products. Limited attention was devoted to longer-term development of change-process strategies or resource building for enhancing R/D&I system capabilities. Concern with developing the field's knowledge and technology base had lost center stage and was not only slighted -- but many of the funding policies and strategies of this period were even inimical to this goal. Considerable resources went into building an institutional structure for a new, specialized R/D&I system -- but little of that funding was used to develop institutional capabilities for longer-term system development. Proportionally less and less of available R/D&I resources flowed to the universities, and more and more went to the regional laboratories and the proliferating non-profit and for-profit corporations geared to the marketplace of federal grants and contracts.(1, 83, 93)

C. Stage Three: NIE and Mixed Strategies

We made the point earlier that any complete picture of federal sponsorship of educational R/D&I activity requires consideration of a host of federal agencies other than NIE -- that despite NIE's role as lead agency for educational R&D, its FY 1975 budget of $74 million represents only a small portion of the total federal FY 1975 investment of $513 million. However, there is little in the published literature that is helpful for developing a clear picture of the goals, priorities, policies or strategies of these other federal sponsors. Our impressions of the contrast between current NIE emphases and earlier OE emphases may need revision after some future analyses are written of R/D&I policies of all the relevant agencies over the past decade or two. But for the present, since NIE is the lead agency for educational R&D and the system's most visible focus of policy determination, it seems useful to contrast what appear to be the dominant patterns in NIE goal-setting/policy determination for the system in the '60s.

Goal-setting and policy formation under NIE appear to present a rather different pattern -- a more collaborative mode and a mixed strategy of centralized and decentralized initiatives. Compared to the previous periods, the NIE approach appears to be less R&D-oriented and more market-oriented. Whereas the previous patterns emphasized first developing the field's knowledge base (1954-64) and then solving educational problems through R&D packaging of solutions (1964-1972), the NIE emphasis appears to be clearly on improving educational practice. R&D activities still receive a very large share of available resources, but dissemination, implementation/utilization, and building internal user system capabilities receive considerable attention in the new strategy. The federal role in the KU-oriented programs is seen as largely facilitating and coordinating, and much of the initiative in goal setting and problem definition is decentralized in the State and Local Education Agencies. Substantial sums are flowing to these State and Local Education Agencies, and several of the programs supported are oriented toward long-term capability-building goals rather than short-term product development.(86) A significant amount of emphasis in the NIE strategy has shifted from product development and product advocacy to change process advocacy and change process capability development.

Still, the older bureaucratic mode of goal setting appears to have persisted in many of those NIE funding programs oriented more toward the KP than the KU end of the KPU spectrum. The locus of goal setting in research and R&D has remained largely centralized in the hands of the NIE staff and their advisers from the field, with resultant continued dissatisfaction among the research and R&D communities about existing goals, priorities, policies, and strategies. A number of initiatives have been taken to involve researchers from a few research areas in the definition of research agendas for their fields; (e.g.:

conferences sponsored by the Basic Studies and Basic Skills groups of NIE(132)). But as yet, the research and R&D communities have not had anything like the influence of researchers in some of the scientific disciplines. Increasingly, there have been calls for a strengthening of the research and R&D communities and the development of mechanisms to permit the field to exercise leadership in defining goals and research agendas.(38) We may, then, in time see yet another metamorphosis of goal-setting and policy formation in educational R/D&I, with significant implications for R/D&I priorities, strategies, and funding programs.

V. ADMINISTRATIVE PROCESSES

As is typical of any newly developing R/D&I system, concerns for management and policy making processes have taken a low priority as compared to programmatic concerns. The dilemma is classical. Those who are most likely to initiate an innovative thrust are least likely to see the need for or pay attention to effective performance in the "mundane" problems of institutional management and the "dirty" problems of policy making. This has been the situation in educational R/D&I. Little attention was given in the past to such issues at the practitioner level, and management for educational R/D&I was not seen as a major and necessary aspect of the agenda of federal funding programs. With increasing maturation, again as is typical, concerns in these areas have begun to appear. Problems of organizational design, personnel management, project and portfolio selection, control and evaluation, cash flow management, information management, etc., have begun to plague managers and policy makers. NIE has begun on a modest scale to support some studies of management and policy making processes in R/D&I. The time would thus seem ripe for a major expansion in research and training programs devoted to upgrading the quality of management and policy making processes.

In this report, we will limit our comments to the above brief overview. In a later volume, we will provide a detailed discussion of the administrative processes function at the generic level. Analysis of the administrative process function within educational R/D&I per se, then, remains an item for analysis at some future time.

VI. PERSONNEL BASE

1. A Critical Weakness

The personnel base of the education operating system in this country is well over three million.(93) However, relatively few of the instructional and administrative personnel who staff this operating system carry out significant R/D&I activity, and we will focus our attention here on the specialized educational R/D&I personnel base.

The specialized educational R/D&I personnel base has undergone substantial development in the past decade or so. In comparison to the mid-'60s, the educational R/D&I personnel base has doubled (perhaps tripled). The best estimate was that the R/D&I system personnel base in 1964 totalled about 4,000 persons.(19) In 1974, several estimates suggest a mean figure of about 10,000 persons (estimates ranged from 8-12,000, and higher or lower estimates can be found, depending on one's definition of an educational R/D&I system).(93) Still, the personnel base of educational R/D&I may be the most critical system weakness - - and the most difficult to overcome. The literature suggests that the educational R/D&I personnel base is inadequate in sheer numbers;(19, 63, 93) is disproportionately concentrated in research, evaluation research and development;(63, 93) is critically sparse in dissemination; and almost totally absent in functional specialties that are just emerging or have yet to emerge (e.g.: need identification, acquisition, and implementation/utilization support). The field suffers particularly from the lack of an adequate supply of trained or experienced R/D&I managers, or even an appreciation of R/D&I management as a function that could benefit from specialized skills and training.(35)

2. The Sources of Personnel

By training and professional background, educational R/D&I personnel tend to come out of either the psychology/sociology statistical research tradition and the university environment(93) or out of school system positions (e.g.: teachers or administrators). With few if any training programs geared to producing R/D&I specialists (and the few that have been available geared more to the pattern of academic project research rather than programmatic development), on-the-job training has been the primary mechanism for producing personnel with appropriate skills and competencies -- an inefficient strategy at best. Some initiatives have been taken to develop training programs m[illegible] suitable to the needs of educational R/D&I functioning (e.g.: dissemination and utilization training programs supported by NIE). But as yet, it is too early to detect a significant change in the character of the system's personnel base.

3. Some Seemingly Intractable Problems

The recruitment, training, and socialization of a talented personnel base for educational R/D&I will require overcoming several seemingly intractable problems; for example:

1. the low prestige of education, educational research, and educational R/D&I;

2. the orientations of most of those who come out of university settings toward advancing theory rather than improving practice; toward individualistic rather than team functioning; toward relatively homogeneous rather than heterogeneous personnel skill mixes; toward producing publications rather than products or programs; toward a professional rather than a bureaucratic style of functioning and management;(28)

3. the complexities of developing suitable training programs, given the ambiguity that surrounds the definition of work roles, requisite skills and standards for various functional specialties in the field.(35) and the weakness of the existing knowledge base;

4. the instability of R/D&I funding;

5. the insecurity of R/D&I positions compared to tenured university posts.

4. Policy Issues

There has been much criticism of educational R/D&I for its failure to attract eminent researchers and first-rate younger talent from the disciplines. But is it possible to attract talented personnel to educational R/D&I, given the present poor quality of system outputs and the resultant inability to overcome the system's low prestige? Is it reasonable to try to intervene now in the maturation of the system's personnel base? Or, is it wiser to concentrate resources on a few key projects where the critical mass of talent already exists and impressive levels of achievement are within reach? Will a few exciting high quality R/D&I outputs do more to attract talented personnel than resource-building strategies focused on recruitment and training? High level debate on these questions would seem to be in order, leading, one would hope, to long-range planning of interrelated product development and resource-building strategies to speed system maturation.

Our knowledge of other R/D&I systems suggests that the rate at which the personnel base can be expanded varies among R/D&I system functions. In research (and to a lesser extent, development), the rate is dependent on the number and size of the existing centers of excellence (which alone can provide the training) and is a long term process. For the linkage functions (dissemination and to a lesser extent development), training programs can be developed at relatively modest levels of funding and personnel trained within a relatively short time frame. However, training in these functions will be constrained by (1) rates and levels at which users can reasonably absorb their outputs and (2) the relative lack of codification in the knowledge/technology bases. Thus, merely investing dollars in training is not always wise or effective.

VII. FUNDING

The funding of educational R/D&I suffers from five key weaknesses: insufficient diversification of sources, low levels, scattering of allocations, instability, and inadequate data base about distribution of funding by functions and performer organizations.

1. Insufficient Diversification of Sources

The federal government has become the primary sponsor of educational R/D&I. A small portion of overall R/D&I funding is provided by private foundations, and an infinitesimal amount is provided by state and local governments and private industry. Several analyses of funding data are currently under way, and the precise figures may need revision when these are completed. However, for the present, we can arrive at a reasonably good picture of the level and sources of educational R/D&I funding from the best analyses available to us at this time. According to those sources, in FY 1975, total funding for educational R/D&I in this country, from all sources, fell somewhere between $605 million and $673 million (depending on what is included or excluded in a given estimate), with $619 million the most likely figure. Of this total sum, approximately 83%, i.e., $513 million, came from federal government departments or agencies.(102) The bulk of this funding is provided by the Education Division of HEW, with most HEW funds obligated through the Office of Education and the National Institute of Education. Other federal agencies providing substantial sums for educational R/D&I include the National Science Foundation and the Public Health Service (particularly the National Institutes of Health and the Office of Human Development). Additional smaller sums flow to educational R/D&I activities through the Department of Agriculture, Department of Defense, Department of Interior, State Department, Department of Labor, National Endowment for the Humanities, Smithsonian Institution, and other federal agencies.(102) The remaining sources of educational R/D&I funding include: state funds, $40 million ($30 million to $60 million); local government funds, $4 million ($2 million to $10 million); private foundations, $57 million ($57 million to $65 million); and other private sector sources, possibly (but here estimation is especially difficult) $5 million ($3 million to $25 million).(93) Greater diversification of sponsorship seems essential given the political vulnerability of educational R/D&I (and thus its funding) in a climate of limited system legitimacy and lack of confidence in the system's ability to produce a reasonable return on the taxpayer's investment. Clearly, though, substantial investment in educational R/D&I by the private sector or by state and local governments is unlikely unless imaginative new incentives are provided and bold new initiatives are taken to attract this new sponsorship.

2. Low Levels

Educational expenditures by all levels of government amount to approximately $55 billion. Appropriations to educational R/D&I account for only about 0.3% of that total.(72, 103) The inadequacy of this funding level is underscored by comparison with other sectors -- e.g.: 3.4% to 5.0% of expenditures in the industrial sector for R&D; 4.6% in the health sector; 1.1% in agriculture; and as much as 10% to 14% of the Department of Defense budget.(23, 49, 72, 103) Given the immaturity of educational R/D&I compared to these other sectors and the need for expensive capacity-building programs, the low level of funding available to support educational R/D&I becomes especially problematic.

3. Scattering of Allocations

The difficulties posed by low overall funding levels are complicated further by allocation patterns that tend to disperse what little money is available over a large number of projects rather than concentrating it sufficiently on a few. The trend in recent years has been toward greater and greater concentration of funding, as more and more projects and programs have lost funding and increasing numbers of federally supported R/D&I institutions have gone out of existence. Still, given the limited funding available and the high costs incurred by large-scale educational R/D&I programs, greater concentration would seem essential if effective programs and products are to be produced.

4. Instability

Instability of funding has been one of the most serious problems confronted by the educational R/D&I system over its brief history. The early promise of ample funding for educational R/D&I was clouded within only a few years. Funding for different types of R/D&I activities has tended to ebb and flow with frequent shifts and fluctuations in federal R/D&I priorities. Federal reliance on annual rather than longer-term funding cycles was a frequent cause of complaint in the early years of the system. While all federally funded sectors suffer to some extent from such instability, the problem has been especially critical in the education sector because of its relative immaturity.

Pleas have been made for longer-term funding commitments to permit long-range planning of complex multi-year projects, and some modifications of funding policies in this direction are apparent. Still, it would seem that greater long-term stability of funding will be needed to attract first-rate personnel and sub-contractors to educational R/D&I.

5. Inadequate Data Base About Distribution of Funding by Functions and Performer Organizations

As we noted just above, available data do suggest that scattering of allocations is one of the weaknesses of educational R/D&I. As yet, our data base is inadequate to systematically analyze the distribution of allocations. However, NIE is currently doing a survey of educational R/D&I performer organizations. When this is completed, we will be in a better position than now to estimate the relative size of actual funding allocations by functional areas of R/D&I activity. Thus, we will also be in a better position to determine the extent to which the available resources are apportioned in a manner that provides the appropriate balance among functions (taking into account the overall stage of development of the R/D&I system and any necessary corrective actions that may be needed to redress previously out-of-balance conditions).

Various data sources available at this time (using somewhat different definitions and classification schemes) provide rather disparate estimates of the distribution of federal funding for educational R/D&I among groupings of functional areas. For instance, a recent description of one data set for FY 1975 projects in the areas of early childhood and adolescence suggests that 80% of this funding was allocated to a category described as applied R&D; 8% to basic research; and 12%, to a group described as planning, dissemination, utilization, and evaluation.(93) Another data set (using a differently bounded data base and a different classification scheme) provides a different impression of the distribution of federal funding for educational R/D&I in FY 1975. These data suggest that knowledge production activities (defined here to include research, evaluation, and statistical activities) have received only 17% of federal funds, while 40% was allocated to a category described as applications formulations (materials development, policy formulation, demonstrations, and social experiments), and 43% to utilization (dissemination and implementation activities).(76) Still other even more recent reanalyses of these same data by NIE's R&D System Support Division staff suggest slightly different figures, and these reanalyses are still in progress. Data from the current NIE survey of educational R/D&I performer organizations may be helpful in clarifying some of the inconsistencies.

The current survey may be particularly useful also for shedding light on questions that have arisen about the relative distribution of funding (from federal and other sources) among the various organizations that comprise the institutional base of the educational R/D&I system. NIE funding data, for instance, indicate that more than half of all NIE awards between FY 1973 and FY 1975 were made to fewer than 50 organizations.(93) It would be useful to have similar information about awards from other sponsors of educational R/D&I activity and to then explore the meaning and implications of such data for understanding the institutional configuration of the system; the location and degree of concentration of certain kinds of R/D&I functioning; the distribution of R/D&I capabilities (and implications for system capacity building); sponsor-performer relationships within the educational R/D&I system (and implications for funding/procurement policies); etc.

A substantial data base is currently being developed and analyzed to shed light on such questions, and additional studies under NIE's Education KPU Monitoring Program are in planning. As more of this information becomes available, we will be able to develop a more complete picture and a better understanding of the funding of educational R/D&I.

VIII. INFORMATION FLOW

There are three distinct information flow systems in the education sector:

1. KP information flows among educational researchers and R&D personnel generally working in organizational settings external to the user system;

2. information flows among user system personnel;

3. information flows between external research and R&D personnel, on the one hand, and user system personnel, on the other.

All three information flows are weak and inefficient. Each has distinctive problems that impede effective communication and information flow and therefore slow:

1. the cumulative development of a high quality knowledge and technology base for the field;

2. the development and dissemination of research and R&D outputs to solve educational problems;

3. the utilization of research findings and R&D outputs in operating systems.

1. Among Educational Researchers and R/D&I Personnel

The educational research community has a well developed formal information flow system that includes annual meetings of the AERA; primary publication outlets; and secondary publications that provide syntheses and critical reviews of the literature and that provide mechanisms which facilitate information retrieval from written sources. However, scientific information exchange in education is more unstructured, random, and far less efficient than information flow in many other fields.(96, 97, 98, 99, 101) The educational research and R&D communities lack well developed informal communication mechanisms analogous to the "invisible colleges" that have been identified in some other fields of knowledge.(32, 33, 111)

Informal communication networks are critical in order for a researcher in a given research area to be familiar with work being done by others that would be potentially relevant to his own investigations. Informal networks are also critical to permit researchers to contact other researchers who can facilitate their information searches and minimize random information-seeking behavior.

Further, the absence of such informal communication networks to structure and channel information seeking behavior magnifies whatever time lags, lack of adequate abstracting and retrieval mechanisms, and other problems characterize the formal information flow system of the field.(32, 100, 101) Thus, the absence of informal networks handicaps the educational researcher.

The development of a cumulative, high quality knowledge base for the field is dependent on improving the efficiency of information flow processes -- but there are few signs of progress in this direction.

2. Within the User System

Information flow within the user system is generally retarded by various norms and patterns of functioning that tend to isolate operating system personnel from one another: e.g.: anticollaborative norms that assume the creative teacher generates ideas and teaching approaches on her own rather than using ideas and approaches developed by others; timidity about discussing classroom problems for fear of being judged inadequate; bureaucratic rather than colleagial modes of functioning that isolate the teacher in a classroom full of children and provide few opportunities for teachers to stimulate one another, exchange ideas, etc.(26, 27, 119, 125) Research suggests that most teachers do not scan the professional literature in search of ideas or solutions to problems, but instead rely on interpersonal exchanges as their main source of information.(17) Given the fact that there are relatively few opportunities for such interpersonal exchanges in most school settings, information flow is therefore minimal.

3. Between User System and Research/R&D Personnel

Information flow between user system personnel and research and R&D personnel in KP organizations external to user systems is hampered by even more serious problems -- differences in values; norms; ways of thinking and conceptualizing problems; ways of describing and bases for verifying assertions; usage patterns; little if any overlap in the journals or magazines they read (or publish in) or the professional association meetings or conferences they attend; etc.

4. Trends and Initiatives

Some progress is being made currently to overcome the barriers to information flow within the user system and between user systems and external KP organizations. One important initiative is represented by NIE support for programs to develop internal problem-solving capabilities through organizational development and other participative renewal strategies (e.g.: the Local Problem Solving Program). Another is represented by NIE's active, interpersonal dissemination and technical assistance strategies to facilitate KPU information flows (e.g.: the Education Information Centers and the R&D Utilization Program).

However, despite AERA interest a few years ago in strengthening research communities and developing more effective communication mechanisms analogous to invisible colleges,(38) the Association has done relatively little to structure information flow in the field into more orderly patterns. There has been a vacuum of leadership in this critical area; and in the absence of any initiatives to improve information flow among education researchers, the knowledge base of the field remains weak and fragmentary and R/D&I functioning remains inefficient and relatively ineffective.

IX. INNOVATIONS

1. Widely Varying Attributes and KP/KU Requirements

Educational products and innovations vary widely in attributes and attendant KP and KU requirements. They vary in the state of the art of the relevant technologies; scale, costs, and level of R&D effort required; in type (categorized as hardware vs. software); in target functions; in demand levels and life cycles; in quality and relative advantage over competing products and practices; in testability and communicability of effects; in complexity; in compatibility with user system constraints and therefore user requirements.

Given this variability, any attempt to provide a modal description of educational products and innovations seems risky. However, to facilitate comparison with other sectors in our analysis, it seems useful to consider a number of generalizations about educational innovations that are probably valid for the overwhelming majority of products and innovations in this sector. We have noted some of these points earlier in our discussion of why the education sector is so vulnerable to environmental influences.

2. High Development Costs

Educational products and innovations that are rigorously developed and tested tend to have relatively high developmental costs. This is attributable to a large extent to the weaknesses of the existing knowledge base of the field and the resultant need for conducting an extensive amount of applied research preceding and during the development phase. Gaps in the knowledge base of the field entail more unknowns. Weaknesses in the relevant technologies entail more trial and error. The transforms between stages (from conception; to specification of design requirements; to prototype development; to development of successively refined versions of the final product) are less efficient, less predictable, more time-consuming, and more costly.

3. Product/User Reactiveness

Educational innovations tend to involve "people change" rather than installation of technology.(59, 61, 74) As such, educational innovations are harder to package, more difficult to market and get adopted, and harder to install. There is far greater reactiveness between product and users, and therefore the implementation process is more difficult and more implementation supports are needed. Product and innovation management strategies for the education sector, then, if they are to be effective, must take into account product attributes that are likely to affect user system willingness to adopt and capability to implement a given innovation. At the present time, however, integration of KU requirements into KP planning and activities appears to be the exception rather than the rule. As a consequence, externally developed R&D outputs have not been diffused widely or had notable impact on educational practice.

X. NEED IDENTIFICATION

Overall, need identification in education lacks coherence and strength.

1. Lacking: An Institutionalized Need Identification Function

Need identification is one of the functional specialties of mature R/D&I systems that is generally lacking in education. There are relatively few examples in the education sector of systematic, ongoing analyses of routinely collected data, cyclically reviewed as part of an institutionalized need identification function focused on needs assessment, capabilities assessment, and long range planning. Instead, whether we examine the process by which needed R/D&I activities are defined by KP institutions or the process by which needed R&D acquisitions are identified by KU institutions, need identification in education tends to be episodic (or, at best, attuned to the annual funding or budget cycles of R/D&I sponsors).

In further contrast to mature R/D&I systems (where need identification processes are institutionalized in specialized organizational arrangements), the loci of need identification in education tend to be scattered throughout the R&D and operating systems and their environment -- researchers, developers, R&D entrepreneurs, R/D&I sponsors, and R/D&I institutions; policymakers and administrators at the federal, state, and local level of the operating system; teachers and other operating system personnel who interact directly with students; school boards and their parent and community constituencies; and perhaps most prominent of all, the Congress, the courts, and various social movements such as civil rights, ethnic pride, feminism, etc.

Need identification in education, then, lacks formalization, and its openness to environmental influence is so great that the system lacks adequate buffers against extremely high levels of demands too varied to be met adequately.

2. Bases

Several bases of need identification are operative in education.

A. Intuitive Judgment

Intuitive judgment is the basis of what is probably the largest proportion of all need identification in the sector. There are several patterns of intuitive need identification in education: spontaneous insight; solicitation of staff or expert opinions; comparing what exists at a particular point in time in the programming of a particular R/D&I or operating system institution and what exists somewhere else.

B. Opportunistic

An additional pattern of need identification in education is basically opportunistic in nature -- the impetus comes primarily from the existence of a resource and only secondarily if at all from the existence of a problem. The availability of a resource (e.g.: funding or a new technology or an available talent pool) and its potential for use in a beneficial manner are what in fact suggests the need.

C. Data - Based

Probably the least frequent basis of need perception in education is empirical data. Two kinds of data-based need identification can be distinguished: one-time analyses of particular pieces or bodies of data, collected primarily for some other purpose but used on an ad hoc basis to identify a particular need or set of needs; and systematic, ongoing analyses of routinely collected data cyclically reviewed as part of an institutionalized need identification and long range planning function.

3. Vaugeness of Requirements

The process of translating perceived needs into innovation requirements specific enough to guide research and development is barely evident in education. More often than not, the need identification process ends with a statement no more specific than "a program to improve students' self-concepts" or "a program to raise reading achievement levels". Rarely does the need identification process in education produce a problem analysis sufficiently detailed to pinpoint either specific elements in the problematic situation (or condition in need of change) or the kind of program or product necessary to bring about desired changes.

Given the social science base of the field of education, there is a somewhat limited intellectual consensus on the one hand and a good deal of value-laden disagreement over goals and needs on the other. This puts a premium on vagueness -- i.e.: the vaguer the statement of a need, the easier it is to achieve agreement. Needless to say this complicates the problem of articulating needs in a manner that translates easily into innovation requirements.

Equally significant in its impact on needs articulation, education has an inadequate and uncertain knowledge base and an ambiguous technology. It is difficult to define problems or to know what is needed to solve them. Consequently, people have a difficult time identifying and articulating needs; thus, people also tend to generate statements that are too vague to be genuinely useful. In those atypical settings where an extensive amount of need articulation occurs, there are specialized organizational arrangements to translate vague perceptions of need into innovation requirements (e.g.: R/D&I organizations that use evaluative data on existing products as the basis of defining needs and planning R&D for future products; or R/D&I sponsors who elaborate R&D contract requirements through mechanisms like the RFP).

4. Decision Structures

Probably the greatest weakness of the need identification function in education is in the decision structures through which need statements are screened and appraised before R/D&I resources are committed. Lacking is an adequate data base against which to judge the feasibility of responding to various alternatives identified as needs for R/D&I activities -- feasibility in terms of the existing knowledge base; capabilities for meeting various needs; and marketability of various kinds of products to meet given needs. Lacking too are adequate mechanisms for bringing together the perspectives of both the KP and the KU ends of the KPU system in education to jointly define needs and priorities and jointly consider existing capabilities to meet a given need by new R/D&I activities (or alternatively, to adopt or adapt existing products or programs from the full array of available practices, programs, and products capable of meeting that need).

5. Recent Initiatives

Recent NIE initiatives have been directed toward strengthening need identification processes. The dissemination and local problem-solving programs of the Institute are basically capability-building programs: the intent is to build local capabilities for problem definition and to link user system personnel to KP resources that can be applied to solving locally defined problems. Similarly, NIE's increasing use of invitational conferences to define research agendas and needed R/D&I activities has been motivated by the desire to bring the research communities from education and the disciplines into the need identification process with maximal efficienty -- getting simultaneous input and feedback from the leaders of a given research area, and at the same time developing some consensus on priorities and disseminating these to the field (e.g.: conferences sponsored by NIE's Basic Studies and Basic Skills groups).(132) However, as yet, there is only limited evidence of overlap between the highest priority needs identified or acknowledged by practitioners and those identified and acted upon by external research and R&D organizations. Consequently, need identification at the KP and KU ends of the educational KPU system show limited integration, and the effectiveness of R/D&I functioning throughout the system is limited accordingly.

A hopeful sign is the substantial amount of effort currently going into the development and use of ongoing management information, monitoring, and assessment systems on the state and national (and to a lesser extent even LEA) levels.(31, 42, 80, 95, 118) It is still too early to expect to find significant impact from these new developments -- but clearly, as assessment systems and long range planning units get better established in the education sector, we should look for evidence of major changes in the manifestation of the need identification function in education.

XI. GENERATION/RESEARCH

1. The Focus of this Discussion

The term "research" may have a variety of connotations and meanings -- and is often used very loosely in the education sector. Thus, it is important that we first identify what "types" of "research" will be the focus of this discussion.

A. "Disciplined Inquiry"

In this discussion, we shall be concerned only with "research" in the sense of "disciplined inquiry" -- the conduct of systematic empirical investigations or the application of disciplined qualitative inquiry approaches (e.g.: historical, anthropological and political science modes of investigation) to education-related questions. Who conducts the disciplined inquiry is not at issue here -- the researchers may be those who identify themselves as educational researchers or as researchers working within a particular discipline. Within this framework, we thus include both basic (or "pure") research and applied research (i.e.: research oriented toward either product development or toward institutional and policy research concerns).

We recognize the limitations of the "pure vs. applied" usage. Still we find it helpful to think about educational research in terms of three categories:

1. basic research;
2. applied research*
3. applied research to inform policy decisions.

We also recognize the somewhat arbitrary nature of our division between the forms of institutional and policy research that we will include here and others that we will categorize later under the concept of evaluation research.

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*In another analysis (115) we used the descriptive term "problem-focused research" rather than the more common term "applied research" to highlight the difference in focus between basic and applied research. Here, however, we will use the term "applied research" because of its common usage.

Finally, we do consider that, properly conceived and done (i.e.: as "disciplined inquiry"), evaluation is a form of research. Thus, we use the term "evaluation research" rather than "evaluation". However, because of its special nature and its usage at the utilization end of the R/D&I process, we treat evaluation research as a separate feature later.

B. Non-Systematic "Research"

We specifically exclude from our discussion of the research enterprise various quasi-research activities that are typically labelled as educational research and divert a fair amount of research funding away from disciplined inquiry, but use methods and serve purposes rather different from those of systematic research -- e.g.: school surveys, statistical surveys of the social bookkeeping variety, social action projects, dissemination and demonstration projects, and development work.

C. The Focus of This Discussion

Research is only one of several bases of innovation and product development in the education sector. Few of the dominant educational practices in schools are based on research findings. Insight, inspiration, and analysis of a relatively unsystematic sort are the bases of much conventional educational practice. Where information is sought to guide translation of ideas into practices or materials, informal interpersonal communication or more formalized library research approaches are considerably more common search strategies of the operating system than the conduct of systematic empirical investigations or application of disciplined qualitative inquiry approaches. We know relatively little about these nonscientific approaches to the generation/research function in education, though this situation may change as increasingly more attention is devoted to documentation and analysis of local problem-solving strategies in the operating system (work currently in progress by the Center for New Schools, supported by NIE).

We know considerably more about the condict of disciplined inquiry in the education sector, and it is this disciplined inquiry that has been the focus of R/D&I policy concern.

2. Issues and Problems of Educational Research

The educational research enterprise faces many of the same dilemmas as research in other fields, especially other applied social science fields. There are the universal issues of quality control -- of particular importance in education, where evaluations consistently show poor definition of educational research questions; inadequate methodological rigor; inadequate grounding in theory; and low ratings of the quality of most educational research outputs.(113, 140, 142, 144) There is also the omnipresent issue of appropriate methodology -- debated in education in terms of the strengths and weaknesses of experimental (or quasi-experimental) vs. the less controlled designs in the field settings in which most educational research is conducted.(10, 53, 135) A related issue concerns the inappropriate application of various statistical techniques in data analysis.

Several of the generic research issues that cut across all social science fields (and perhaps other sectors as well) are particularly pronounced in education because of the nature of the field's knowledge base, the nature of the demands made on the educational research community by external environmental forces, and the deep strains in relationships between researchers and practitioners. Instances of these generic issues that take on particular salience in education are: how to produce interdisciplinary cooperation; how to determine priorities between basic and applied research; and how to protect subjects and operational settings from unwarranted interference by researchers.

A. How to Produce Interdisciplinary Cooperation

Education is a conjunctive domain of knowledge -- i.e.: a field that focuses the perspectives of several disciplines on understanding and solving certain social problems.(133) Since as many as twelve (or more) disciplines converge on inquiry in education, interdisciplinary cooperation and cooperation between educational researchers and researchers in the other disciplines become all the more important -- but no less easy to attain.

B. How to Determine Priorities Between Basic and Applied Research

The debate between basic and applied researchers in education is phrased in terms of the weaknesses of the field's knowledge base (how little or how much we know at this time to guide program or product development) vs. the immediacy of the problems in need of solution. Thus arguments can be made in support of basic research at the expense of applied research -- for example: the contention that R&D programs at this time are premature and ill-conceived because the basic knowledge base is inadequate; the argument that applied work is ineffective in solving problems because it is framed in terms of existing conceptions that are inadequate and will remain so until basic research produces major breakthroughs that affect the way we think about problems as well as the knowledge and technology we apply to them. However, other persuasive arguments can also be made for applied research at the expense of basic research -- for example: the argument that we already know a great deal that is useful for solving pressing problems that cannot await maturation of the field's basic knowledge base; or that effective solutions can be developed if the available knowledge base is effectively transformed and structured in a manner that facilitates application.

Work now in progress will soon provide us with a better picture of how much support comes from which federal agencies (and other sources) for basic and applied research (e.g.: analyses currently being conducted by staff members of NIE's R&D System Support Division) and will place us in a better position to make judgments of the adequacy of the level of funding for system development. Numerous criticisms have been made of basic research funding in particular --that it has been relatively small in scale (and overwhelmed by proposals relative to available funds); has not been designed in accord with any overall basic research strategy; and has lacked either continuity or high visibility.

There were many high hopes for NIE in connection with basic research in the months prior to its creation -- but NIE has not become the think tank of eminent scholars that NIE proponents envisioned and argued for. Instead, funding problems have forced cutbacks in the small basic studies unit within NIE; allocations for basic research grants have remained relatively small; and earlier initiatives to strengthen basic research (e.g.: the four-year funding of COBRE, the Committee on Basic Research in Education) have not been continued.

The COBRE project was of particular importance. It had an eminent organizational setting (the National Academy of Education and the National Academy of Sciences - National Research Council). Eminent scholars served on the Committee. Its task was "to identify problems to be attacked by basic research in education and to develop and try out plans and procedures for stimulating and supporting such research." It had moderate success in attracting both established and younger scholars from the social sciences to basic research in education. Still, it was discontinued.(12, 20, 44)

C. Ethical Issues

Ethical issues surrounding relationships between researchers and human subjects take on added meaning in education where the human subjects are often children and where relationships between researchers and practitioners are often strained. In educational research settings, the need to protect subjects from harmful effects of experimental treatments or from invasion of their privacy is a very important issue. These direct ethical issues raise further issues about the amount of control a researcher can have over the conduct of his own inquiry -- e.g.: the role of the practitioner in defining the problem to be investigated; the amount of manipulation of "treatments" to be permitted in an operational field setting; the needs of researchers for a stable program stimulus vs. the needs of program personnel to keep changing their program in terms of changing needs and understandings of what they are doing.

3. The Changing Character of the Educational Research Community

A. Initially: A University Base

In addition to these various research issues, there are a host of new issues that have emerged out of the changing character of the educational research enterprise. Until the mid-'60s educational research was an activity carried out by a relatively small number of individual researchers who were based in the universities; operated with a great deal of autonomy in defining problems and conducting investigations; devoted a small proportion of their time to research; were oriented primarily to publishing research findings that might add to our understanding and knowledge about educational phenomena; and were regulated primarily by a peer group review system that allocated rewards primarily in the form of prestige and recognition within the scientific community.

B. New Institutional Arrangements

Developments of the past decade and a half have transformed educational research. The educational research community has grown rapidly in numbers and in diversified institutional bases.(88, 93) Although almost all basic research is still carried out in the universities and some applied work is done there as well, non-profit and for-profit research corporations have emerged as a strong competitive force in securing applied research contracts from governmental agencies.(1, 83, 93) Consequently, more and more of this research is being done outside the universities, with serious consequences for research training; for information flow and the cumulative development of the field's knowledge and technology base; and for the manner in which (and the extent to which) research findings get to be disseminated and utilized. The new institutional arrangements for the conduct of research have turned research into a full-time pursuit for a large portion of the research community. Of even greater consequence, these new arrangements have had a significant impact on the nature of educational research and the educational research community. These new arrangements have produced new patterns of research functioning (e.g.: research teams rather than individual researchers). There are new modes of research management and new constraints on researchers -- i.e.: bureaucratic, mission-oriented research management that limits the individual researcher's autonomy in both defining research problems and conducting inquiries.(25) There are new research subcultures with wholly new systems of rewards and controls that weaken the impact of the disciplines on the conduct of inquiry -- e.g.: political and bureaucratic norms are competing with and (for many) replacing professional norms; political influence and economic incentives are replacing scientific recognition as rewards; and agency acceptance and utilization of research findings are replacing peer review of scientific quality as the dominant controls.(28)

C. New Kinds of Accountability Issues

The new prominence of educational research, and the amount of public funds flowing to it, have posed new kinds of accountability issues that may be harder for researchers in the education sector to resolve than researchers in other sectors which have stronger knowledge and technology bases. The Congress has been demanding public accountability for an immediate payoff from its investment in educational research -- without any realistic appreciation of the extended time frame needed to produce results in research in general and in educational research in particular. Thus, we find a "Catch - 22" type of situation. On the one hand, to obtain funding, researchers must provide some promise of a payoff -- regardless of the fact that research by definition involves a not insignificant degree of uncertainty. On the other hand, to make promises which cannot be fulfilled may result in the researcher being funded -- but even more importantly, such unfulfilled promises lead inevitably to public disillusionment and a worsening of the political environment of the research enterprise. The proper stance for educational researchers to take in relation to government agencies, and the kinds of research outputs they should provide (i.e.: solutions, approaches to defining problems and thinking about solutions, or information about the likely or obtained effects of alternative solutions under consideration by policymakers) -- these are matters of serious debate among educational researchers and social scientists in general.(22, 79, 110)

4. The Future

Despite frequent calls in recent years for a strengthening of the educational research community and more field-based initiatives to structure the national research agenda for education,(38) the educational research community remains diffuse, politically weak, and largely reactive to federal initiatives designed by government bureaucrats who are generally not members of the research community. We see relatively little evidence that this situation will change in the near future -- certainly not without NIE support and initiatives.

The strengthening of the educational research community in the future may well depend on collaboration among the leadership of the research community and the key federal agencies and other major sponsors of educational research, with initiative perhaps remaining still with the federal agencies. Our analysis of what is needed is based on consideration of the somewhat distinctive requirements of basic and applied research and the current state of development of the institutional and personnel bases for conduction of the basic and applied research functions.

In thinking about the future of educational research, we will need to review our understanding of the basis upon which it may be assessed and of its current status. From these we may suggest key needs for the future development of the educational research function. We will do this separately for basic and applied research.

A. Basic Research

Assessment Basis

In assessing basic research for education, it is important to recall the interdisciplinary nature of educational research. On the one hand, we said that there is basic research being performed in several disciplines (e.g.: psychology, sociology) which will be relevant to education. However, education is a subsidiary concern of these other disciplines. On the other hand, consideration has also been given to basic research which is done within the field of education per se and which is performed by researchers trained in and committed primarily to education as a field of study. It is this latter focus which is our primary concern here because of the importance of having a basic research function whose primary and ongoing focus and commitment is on the field of education per se -- while at the same time recognizing and utilizing important and relevant basic research in other fields.

As basic research is an uncertain, unpredictable and highly creative undertaking, it is very sensitive to threats to its climate and to the quality and stability of support and funding and is highly dependent on its roots in its fundamental disciplines. Its outputs are knowledge and stimulation and it is only generally in the long term that we can assess its practical contribution. And, given its inherent uncertainties it becomes hazardous to attempt to predict the areas in which such outcomes will occur. But without it the well of new thinking frequently runs dry. It is therefore vital that a healthy and mature R/D&I system will have developed and maintained a substantial high quality basic research component.

Such a component cannot be built quickly. The rate at which quality basic research can be expanded is limited by the size and quality of its existing centers of excellence (which may range from a single outstanding researcher to a team of such researchers). To pump more funding into this endeavor than such centers can usefully absorb can only lead to waste and disappointment. Future growth is (and will be) limited by past investments in creating and supporting a central core of basic research having many centers of excellence. The major problem of basic research within education as a field of study per se has been as we noted in the very weakness of this central core.

Assessment of the basic research function will need then to be based on:

1. The size and quality (based on the reputation of institutions and personnel) of the central core of the basic research function -- most specifically on the size, growth and stability patterns of identified centers of excellence. An important indicator will be the ability to attract and hold top flight researchers.

2. The number of new centers of excellence seeded and taking root over successive (rolling) 3-5 year periods.

3. A measure of the supportiveness of the climate - in terms of funding growth and stability over several year periods.

4. Measures of the quality of the linkage to and reputation of basic research in education and its more fundamental root disciplines (e.g.: psychology, sociology, etc.).

5. Over long (10-20 year) time spans, an assessment of major substantive contributions to knowledge coming from educational basic research.

Current Status

We have seen that basic research in education is generally to be found in two types of settings. That located in schools of education (frequently in such disciplines as educational psychology and sociology) boasts few centers of excellence and much mediocrity. A different picture emerged from viewing the research carried on in discipline based university departments such as psychology and sociology. Excellence and valuable contributions to knowledge are to be found, but what has been lacking here has been a primary and continuous commitment to education. The interdisciplinary character of educational research has added to the diffuseness by making communications and information retrieval (from the large variety of publication sources) very difficult. Altogether, this has added up to an educational basic research community that has been to date unstable and amorphous. It makes system building in this area a major requirement and a critical consideration in funding programs.

At the same time, the general climate for basic research in education as for other (especially social) areas of basic research has been far from supportive. This negative climate has been particularly intense for education which has been hard put to point to more than a handful of significant developments that are traceable to basic research. The low prestige with the general public and with Congress and the associated unreliable funding have made it hard to attract strong talent and this has acted as a major constraint on building the central core. As regards funding, it is vital to note that there are many agencies which fund basic research in education. Indeed, the National Institute of Education (which has been assigned "lead" responsibility for educational research and development) has been a relatively minor contributor to the total funding going to basic research, especially in comparison with such an agency as NIH.

Key Needs

In light of the above summary analysis of the distinctive requirements of basic research and the current state of development of this function in education, the key need would seem to be for a consistent, continuous, stable process of system building. This would include:

1. identifying existing centers of excellence;
2. facilitating the establishment of additional centers of excellence;
3. facilitating the growth of these centers, existing and new;
4. facilitating improved information exchange and retrieval mechanisms;
5. providing stable, long term funding.

B. Applied Research

Assessment Basis

It is important to be reminded that applied research *is* research and shares with basic research a high level of uncertainty and unpredictability. Thus, researchers in particular treat applied research in a basic research *mode*. But it is also *targetted* research. Thus, funders and users often assume it to have the level of certainty and shortness of time line more appropriately associated with development. This deceptiveness and the consequent inherent tension makes applied research subject to considerable instability, misdirection and mismanagement, and consequent misdirected assessment.

Researchers frequently redefine and bend applied research into basic research modes. In particular, they often attempt to undertake projects on smaller scales than are required by the nature of the problems, which often require the efforts of large-scale interdisciplinary and empirically based team programs. This syndrome is often combined with attempts to oversell the timing, probability and impact of outcomes in order to obtain funding. This often succeeds with funders simply because applied research projects do appear to have practical, attainable outcomes. All of this creates an environment that tends to be unattractive to many of the best researchers.

On the other side, users and funders, having been persuaded to fund such programs because of these very expectations of near-time benefits, become frustrated by not only the lack of delivery but also by the shifting targets, time and cost patterns which are inherent in the uncertain research process.

Another important dimension of this tension lies in the problem of need identification. On the one hand, the objective is to work on important and timely problems that require solution, and this tends to be the prime inducement for the users and funders. On the other hand, a researcher is required to maintain the criteria of researchability -- criteria that often significantly limit the utility of the project from the user perspective. This as well as the previously mentioned problems of tension become magnified when one recognizes that the cost and scale of applied research tend to run orders of magnitude higher than what is typical of basic research.

Assessment must therefore be based on judgments of:

1. The quality and appropriateness of the institutions performing this function:
   - Are they capable of mounting the required large scale interdisciplinary efforts?
   - Are they attracting and keeping top quality applied researchers?
   - Are their programs and projects considered to be of high quality, important to practice and on truly researchable problems?

2. Whether applied research is emerging as a definable entity, differentiated from basic research and development.

3. After a time lag that reflects several years of sustained system building, an evaluation of the rate and impact of outputs.

4. The climate for applied research in terms of both support patterns and receptivity to its outputs.

Current Status

Most of the research that is carried on in education appears to be what might loosely be defined as the applied type, much of it unfunded and small-scale. The volume of studies produced may indeed by large -- but being of this small-scale, scattered and fragmented quality, these have been subject to many questions of quality. It is evident (as mentioned earlier) that there is substantial lack of differentiation in education between what can truly be classified as research and various other activities (e.g.: demonstration projects, social bookkeeping, etc.); great weakness in defining researchable problems; considerable fuzziness in differentiating applied research from basic research and development; and the previously mentioned tendency to oversell such projects.

As we noted earlier, applied research in education is largely carried on in two types of institutional settings: universities and large-scale R&D institutions in the private and quasi-public sectors.

Where this work has gone on in universities, there has been a tendency to perform applied research in a basic research mode. This is not surprising given the socialization and prior training of university researchers and the social and publication pressures under which they operate. Generally, universities find it difficult to assemble the minimum critical mass of effort needed to undertake large-scale applied research projects. As a consequence, they have tended to scale such projects down and/or to assemble ad hoc teams that lack long-range stability. With this has come the unfortunate tendency for researchers to move in and out of this part of the field which has mitigated against system-building requirements.

Large scale R&D organizations should have been, and to some degree have been, more suitable sites for such programs. However, two important problems have limited their potential success. Firstly, most of these R&D organizations have not been able to promise a stable career path to researchers, thereby greatly limiting their ability to attract and hold first-rate researchers. Secondly, federal funding practices in the late '60s shifted the character of many of these institutions away from applied research and reshaped them into development organizations in accord with federal priorities at that time for product-centered impact strategies.

As a consequence of the above conditions, education has in fact seen very little applied research. Therefore, this has to be seen as an area that needs to be put together at this time in its own terms and not be thought of as a form of advanced development or downstream basic research.

A number of other problems in educational applied research were previously implied but require further explication. The climate for such research has been perhaps even more negative than that described above for basic research. This has been so precisely because it seemed to hold out more promise of impact and raised expectations than could have been satisfied -- given the inherent time frame and the weak state of the area. Relatedly, need identification, which had been researcher-driven up through the mid-'60s, became system-driven by users and funders in an overreaction to this state of affairs. As with basic research, funding has been realtively limited.

Key Needs

Applied research in education, then, must be seen in a system-building mode.

1. It will be essential to locate those centers of excellence capable of performing large-scale applied research.

2. Such institutions will need to be provided with the kind of long-term stable funding that will permit them to attract and retain top-flight staffs of researchers.

3. It will also be vital for the lead educational funding agencies to help practitioners and the Congress understand the nature and requirements of applied research to:

   understand that project selection requires the determination of what is researchable as well as what is important;

   recognize that the present lack of capacity demands a period of institution-building before the promise of the area can begin to be fulfilled;

   and understand that such institution-building will require an ongoing and long-term commitment.

XII. DEVELOPMENT

As described in the literature, the development function in education adheres strictly to the engineering model of development used in industry. But the development function described in the literature represents only a portion of all development work that is done in the education sector -- the development mode as it is carried out in pursuance of government contracts, primarily in regional laboratories and in some of the non-profit and for-profit research and R&D corporations. If we accept a broader and less rigorous definition of development work, then we must also include several other models of the development function as this is carried out by classroom teachers, by curriculum specialists in SEAs, ISAs and LEAs, by textbook publishers, and in university-based curriculum projects.

1. Development as an Institutionalized Functional Specialty (Using the Rigorous Development Model)

Considering first the rigorous definition of the development function as an institutionalized specialty that is carried out by specialized personnel in specialized institutions or organizational units, development activities are systematic and sequential. Development moves in a smooth progression from prototype design that is the end product of the applied research phase of R/D&I; to product or program development in accordance with detailed specifications; to evaluation of small field tests; to revisions; to larger field tests; to more revisions; to an additional field test; etc. -- until the product performs in accord with the prespecified performance objectives. Products go through successive generations of revisions, each a closer and closer approximation to the performance specifications. Revisions are based on empirical field test data that are gathered systematically and analyzed rigorously. The evaluation data provide the potential user with precise information about the outcome or effects to be expected from use of the product under specified implementation conditions. (60)

Development projects implemented in accord with this model tend to be large-scale and expensive; involve large personnel base pools and heterogenous skill mixes; and involve extensive cooperation between the R&D organizations developing the products and the school systems agreeing to serve as field test sites. The products themselves are often complex, consisting of many and varied modules or components, and often several forms of media as well as printed materials. The management of these complex development projects is often highly formalized, using flow charts and sophisticated management tools. (60, 66, 116)

There may be some variations in pattern depending on the nature of the R&D outcome being developed -- e.g.: products vs. change processes. However, the issues of concern to managers tend to be consistent: How much research is needed prior to the development work? How much research can proceed parallel to the development work? At what point is the product sufficiently developed to permit initial field testing? At what point has the product been tested sufficiently to permit dissemination? What dissemination, marketing, and implementation factors need to be considered throughout the design and development phase? At what point does the responsibility of the developer end: development? dissemination? installation? utilization and maintenance?(7)

2. Development in the Education Sector

These issues are to some extent common to the development function in all sectors, but they take on particular significance in the education sector. The weakness of the knowledge and technology base of the field makes it more difficult to translate performance specifications into effective products. Outcomes are far less predictable given the reactiveness of the user setting and limited technical capability of user personnel to implement complex innovations without substantial implementation supports. Consequently, development work in education requires a far greater investment of time and money in the research and evaluation components of the development process, making development costs high relative to practical payoffs -- a problem of particular importance considering the negative political climate in which educational R&D appropriations are made.

The rigorous model of the development function as it is used in the regional laboratories can be contrasted to the more traditional approaches to the design and development of instructional strategies and materials -- as these activities have been carried out by classroom teachers; by curriculum specialists in the SEAs, LEAs, and the universities; by publishers; and by the university scholars who have on occasion participated in efforts to improve K-12 level curricula and instructional materials in their areas of specialization.

The development approach used in these settings tends to be intuitive rather than data-based or grounded in theory. The focus of attention is generally on the content to be conveyed rather than conception of how students learn or how teachers go about providing instruction. Field testing is nonexistent or minimal. Development costs are relatively low. The personnel involved are relatively few (e.g.: one teacher, a few scholars or curriculum specialists, etc.); and whatever skill mixes are present in a development team tend to be relatively homogenous. Management is generally informal and highly flexible. Where textbooks or materials packages are being developed for large-scale, nationwide dissemination, an effort is usually made to include implementation supports in the form of teachers' guides, tests, etc. Where materials are developed locally for use by a single teacher or a group of teachers in a single school or district, far less of the implementation process is committed to print or media presentation; the state of "development" of the materials or strategies for use outside this small group remains inadequate; and either the locally developed innovations are not disseminated at all or they are disseminated but have minimal success elsewhere because development work was not carried far enough to permit the materials to be implemented easily and effectively by others.

3. Changing Patterns of Federal Support for Educational Development

The rigorous development model is likely to permit more effective implementation of developed products. However, consideration must also be given to the high costs of rigorous development work, the relatively limited utilization of externally developed R&D products to date, and the extensive amount of local innovation that exists. Thus, federal policymakers are giving increasing attention to internal user system development resources -- building internal innovation capabilities; linking internal sources of innovation to external resources for documenting and analyzing local innovations and developing materials that could be used to assist other school systems in implementing these locally developed programs and practices (e.g.: OE programs in support of SEA efforts to identify, validate, and package exemplary practices; NIE-supported programs to build SEA dissemination capabilities and LEA problem solving capabilities). The bulk of federal development resources appear still to be awarded to external R&D organizations that use the engineering model. (We will be in a better position to verify this impression after data from NIE's current survey of KPU organizations are gathered and analyzed.) However, it seems possible that this balance may change in time. If this does happen, the character of the development function (as this is generally understood in the educational R/D&I community) may undergo considerable change, and with it the institutional bases, the personnel base, and especially the technology of the development function.

4. The Future

If the development function in education were mature, we would expect to find a large supply of high quality outputs that are responsive to user needs. Since most available outputs of educational development appear to be weak in both quality and responsiveness, future strategies for strengthening this function must be based on consideration of the essential requirements of the development function and the major weaknesses of each of the two predominant modes of development work in the education field.

As we noted in the discussion of the future of educational research, to think about the future of the development function in education, we will need to review our understanding of the basis upon which the educational development function may be assessed and of its current state. From these we may suggest key needs for the future of the development function in education.

Assessment Basis

As we have noted, critical in the assessment of the development component of an R/D&I system is the recognition of the centrality of its linkages to the user, to production and to the state of art in development. Development has a relatively more predictable and shorter time horizon process as compared to the research functions. It aims to convert knowledge into user-ready products, products which may (or may not) need to pass through a distinct production phase before they can be disseminated or distributed. With the linkage to the user being so critical, so is the requirement for need identification -- a step that is difficult to perform, but one that must be done well and often in an ongoing manner during the development process (where complete identification is not feasible -- as in many areas of social development) if the product selected for development is to be on target.

Development is also highly dependent on the quality of its linkage to the state of the art and on the skills and motivation with which products are designed so as to be capable of production and dissemination. This determines the effectiveness and viability of the product.

Since development is frequently carried out in specialized development organizations it is highly dependent on the quality of such institutions and their personnel and most particularly on their experience. It is important to differentiate the concept of excellence in development from that used in research. In development, excellence is measured by being cost/effective, timely and opportunistic. With such criteria, experience (individual and organizational) and thoroughness (ability to do the whole job) are often more important than brilliance. Where development is carried out in a user setting, then assessment must be concerned with the extent of wider dissemination of the products or processes developed.

Thus, the critical bases for assessment are:

1. Quality of linkages to:

   - users
   - production
   - development state of the art.

   Measures of such linkages are hard to define and obtain, depending as they do upon quality, frequency and form of interaction. They will likely be qualitative in nature, and "observable" more in their absence in terms of problems generated, than in their presence.

   A specific manifestation of this linkage will be in the quality of need identification, to be measured indirectly by the relevance of development outputs for practice, and by the scope and effectiveness of feedforward activity from users to developers.

2. Number and effectiveness of large-scale development organizations. Effectiveness here would be measurable in terms of extent of adopted products and some qualitative assessment of impact (actual and potential).

3. Extent of dissemination of practice-based developments.

4. The number and quality of products developed from the whole R/D&I system and their overall (portfolio) effect. Quality would again have to be measured by usage based criteria although the locus of quality control would be a design variable.

Current Status

As we have discussed, educational development is plagued by a weak knowledge base. The quality of information is poor, very little has been codified. As such, quality control is a central requirement, which has only recently begun to receive serious attention but which is still relatively poorly developed and its enforcement a matter of some diffuseness as to locus of responsibility. With limited ability to depend on quality control in the field, funders and program managers may need to build quality control checkpoints into staged development procurements, a procedure that demands closer involvement and orchestration between key funding agencies and the field than has been typical to date.

We noted earlier that there are two distinctive modes of development work in education:

a. development work that adheres to the rigorous development model and tends to go on in specialized development organizations;

b. more conventional, intuitive modes of development that tend to be carried on as part-time activities in practice-based settings.

At their best, specialized development organizations represent a strong element in educational R&D system capacity. There are a few such well staffed and experienced development organizations and their existence is an important indicator of the system building that has gone on. More often, however, the institutions and personnel involved in development do not come up to these required standards. Even the best of these organizations tend to suffer from isolation from practice, making dissemination and implementation problematical. This may be one of the causes of the limited utilization of R&D based products, a shortcoming that is tending to threaten the viability of this type of institution. There may be a critical need in development not to increase the level of effort overall (there is an inventory of more than half a million R&D products that are available for sorting, tailoring, packaging and dissemination) but rather for a shift of emphasis so as to build up more of the strong high quality development organizations with whom the government can contract and to ensure their closer linkage to practice.

The second basic mode of development in education (practice-based) does not suffer (obviously) from poor linkage to the user. It does suffer, however, from inefficiency, lack of sophisticated skills, poor documentation of its achievements, difficulties with packaging, and from enormous problems in achieving wider dissemination and diffusion. State initiatives have become particularly significant in recent years in identifying, packaging and disseminating exemplary practices and programs developed by local school systems. The verdict is not in as to whether this mode can become a source for wider application (beyond the local development site). Meanwhile, further research on this mode is required as well as support for efforts to supplement and expand local capabilities, possibly through increased linkage and collaboration between practice based development and specialized development organizations.

In the area of project selection the emphasis to date has been on a project-by-project selection process. Missing has been the capacity in the system to consider critical portfolio effects. These could involve decisions to target and concentrate development programs so as to achieve synergistic benefits, staging and sequencing strategies that minimize user disruption and uncertainty, cooperative ventures across agencies, etc. Particularly important may be the need to develop skills in commercialization so as to make better decisions with respect to what to place with which elements of the private sector and when.

Key Needs

With the above in mind, the following would appear to be key needs for the educational development function, particularly with reference to the role of key funding agencies.

1. Work with the field to build up the explicit designing-in of quality control functions into funded development programs - possibly including staged programs with quality control checkpoints.

2. Shift support emphasis to favor those high quality specialized development organizations that show a pattern of being responsive to practice needs and to technical opportunity.

3. Work with SEAs and LEAs to determine the most cost effective ways of identifying and disseminating practice based development products.

4. Study and experiment with strategies designed to improve the interface between the government funded development organizations and commercial firms - - including development of criteria for what should be handled how and by whom.

5. Development of program planning and project selection methods by key funding agencies that give explicit consideration to portfolio effects.

6. Explicit programs designed to achieve inter-agency cooperation for development activities.

7. Study and experimentation with strategies designed to improve the interface between the government funded development organizations and commercial firms - - including development of criteria for what should be handled how and by whom.

XIII. PRODUCTION

Production issues are of minimal concern at this point in the historical development of the educational R/D&I system. As we use the term, the production function is restricted simply to the reproduction or manufacturing in quantity of a fully developed and tested item. All design and development work is subsumed under the research, development, and evaluation research functions. For the most part, production in the education sector takes place in the subordinate system of institutions that provide support services to the educational R/D&I system -- publishers, film production companies, manufacturers of hardware and equipment, etc. These production institutions tend to be sector-spanning in nature, and none of the production issues that come into play appear to be sector-specific to education.

Production issues are of relatively low priority in the education sector. The overwhelming majority of educational products and R/D&I outputs tend to be software rather than hardware; the predominant medium is print; and the key issues of performance and reliability have less to do with possible breakdowns in the production function than with weaknesses in the development function or the implementation process. Commercial publishers generally strive for a high quality print product using costly materials and production techniques. On the other hand, the gloss of commercial publications is generally absent from the outputs of R/D&I organizations. To some significant degree, this appears to be a consequence of clearly articulated policy decisions of educational R/D&I sponsors and contractors. Educational R/D&I decision makers have opted consciously for allocating maximal resources to the research, design, development, and evaluation of the substance of the materials, and the barest minimum to production -- just enough to insure that a sufficient quantity of usable materials can be distributed to operating systems.(7)

Some recent initiatives have been taken to develop collaborative relationships between R/D&I organizations with strong development capabilities and commercial publishers who can add high quality production capabilities (e.g.: arrangements between Appleton Century Crofts and the developers of Individually Prescribed Instruction). However, these arrangements are relatively few in number; the linkages are tentative and experimental; and as yet the production function is barely visible in the configuration of educational R/D&I.

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

The linkage functions of marketing/distribution/dissemination/diffusion have always been among the weakest components of educational R/D&I, and have only recently become the focus of federal and state R/D&I policies. Each of these functions has had a number of traditional meanings, each with its own set of institutions, channels, and characteristic activities. New conceptions of these linkage functions are gaining wider acceptance; and new institutions, channels, and activities are appearing to operationalize the newer approaches.

1. An Emphasis on Information Flow

Until recently, the dissemination function has been concerned primarily with the flow of inf[illegible]ion -- the outputs of research -- rather than the marketing and distribution of packaged R&D products. Further, dissemination strategies have been so passive and uncoordinated that the burden of effort in retrieval was on the researchers and practitioners seeking information. The characteristic channels have been publications -- reports of research findings in technical reports to sponsors or in scholarly journal articles targetted at the research community; or in non-technical form in articles appearing in the magazines and newspapers read by practitioners and laymen. Informal, interpersonal information exchanges took place at professional association meetings of researchers and at other meetings of practitioners, and at occasional conferences, seminars, or workshops. The universities and teacher-training institutions also performed a key role in passing on a field's knowledge base in pre-service training programs, or in updating knowledge and skills through in-service training. For the most part, however, this pattern involved dissemination of individual pieces of information with a potential for application rather than packaged information products designed to produce changes in practice.

The exceptions here were the publishers and equipment manufacturers who packaged information or technological products into immediately usable forms and had well developed marketing and distribution operations to get their products into the hands of practitioners with a minimum of effort on the part of user system personnel.

2. Dissemination in the '60s: The Impact of Federal Policies

Federal R/D&I policies in the '60s added several new dimensions to the then existing modes of dissemination. The crowning glory of the information dissemination policy was the massive ERIC system created by OE to acquire, store, abstract, and provide easy computerized retrieval of sources from the extensive fugitive literature of the education sector. ERIC also provided publications that announced acquisitions to the field and therefore was expected to make them more visible; indexed the journal literature of the field as well as the fugitive literature stored in the ERIC collection; and provided several hundred information analysis products that synthesized information in selected topical areas. (Professional associations of both researchers and practitioners also became active in the '60s in producing targetted information analysis products or synthesis of the available knowledge and technology base in specific research areas -- e.g., the National Education Association's What Research Says to the Teacher pamphlet series; two editions of the Handbook on Research in Teaching;(47, 138) and four editions of the annual Review of Research in Education.(68, 69, 70, 120)) However, ERIC has been repeatedly criticized as geared largely to the needs of researchers rather than practitioners. More recently, in response to practitioner needs, ERIC acquisition programs have included efforts focused on storage and retrieval of curriculum packages and other development products (e.g.: product information packages). As yet, ERIC appears to be used little by practitioners.

The network of institutions created by the federal government in the '60s included organizations charged with responsibility for acquiring and disseminating instructional materials in given areas (e.g.: The Instructional Materials Centers) and organizations designed to demonstrate and disseminate exemplary local practices (the ESEA Title III demonstration centers). Dissemination of the R&D outputs of the laboratories and centers was considered a major function of these organizations. Categorical programs (e.g.: ESEA Title I, Upward Bound, programs for the handicapped, vocational/career education) have always included dissemination components. Additionally, various referral organizations (e.g.: the National Referral Center and Phi Delta Kappa's School Research Information Service) and other more active and interactive approaches to dissemination (e.g.: education information centers with education extension agents(29, 90, 127)) also began to appear in the '60s. Still, despite all these initiatives, by the early '70s it seemed clear that the outputs of educational research and R&D were not reaching the user system to any significant degree or having clearly visible impact on improving educational practice.

3. Federal Dissemination Programs

Current federal dissemination programs have been built on many of the initiatives of the '60s, but carry them further and change the focus of federal dissemination strategies. Historically, the overall federal strategy could be characterized as:

1. initially one of laissez-faire(112) (prior to the mid-'60s and in the initial conception of ERIC as a passive information repository);

2. then a strategy of product advocacy(112) (the Instructional Materials Centers, laboratories and centers, and Title III demonstration centers advocating the use of particular products or programs they selected or developed);

3. and finally, strategies of

   a. coordination of existing discrete efforts,(40, 65) and

   b. change process advocacy,(112) replacing advocacy of particular programs and products with informational and capability building approaches: providing extensive amounts of (and easy access to) information on the full array of available products, programs,

> and practices to meet given needs; providing easy access to education extension agents in local education information centers; developing users' capability for evaluating, adapting and implementing the products of their choice. (29, 83, 94)

The federal role is seen as one of facilitating, coordinating, and providing start-up funds to mobilize state and local dissemination resources. The focus is on building networks that bring together and strengthen the dissemination resources of existing organizations that carry out dissemination activities, especially the SEAs. (89)

The approaches that have been funded tend to be active and interpersonal -- e.g.: working through educational extension agents, local education information centers, networks of consultants, and interactive computerized retrieval mechanisms. Educational extension agents and other personnel working in local districts are linked to centralized resources and specialists; information needs of local users are determined; information and materials required to meet these needs are transformed into packages tailored to the user's needs and constraints; and followup supports and feedback mechanisms are built into the overall design. (29, 127) To date, these systems have been developed extensively in relatively few states, though the number and scope of these programs are expanding under NIE dissemination capacity building grants to states. Clearly, this active, interpersonal, user-oriented and field-based networking strategy is the direction in which educational dissemination in the U.S. is moving at this time.

4. The Current State of Dissemination

Clearly, the institutional base of the dissemination function has undergone extensive development in recent years. Considerably more expansion is likely if NIE's Research and Development Exchange program (currently in the planning stages) becomes operational. Nonetheless, it will be some time before we can expect to find substantial impact in the form of widespread improvement in educational practice. There have been serious efforts to synthesize the theoretical knowledge base of the function,(55, 58) but the translation of this knowledge base into usable strategies with known effects is only beginning. The dissemination specialty is only now beginning to appear and is clearly inadequate for the scope of existing programs such as the Research and Development Exchange program noted above. Most of those currently carrying out dissemination activities appear to be practitioners by training. They are proceeding intuitively and learning the dissemination field on the job. Few programs are available to train dissemination specialists.

Until recently, the linkage functions of marketing/distribution/dissemination/diffusion have been among the critical gaps in the educational R/D&I structure. There are hopeful signs that dissemination and diffusion are maturing. But despite all the discussion in recent years of bringing a marketing approach to education,(5,62) and despite the current focus on user needs and user viewpoints,(83, 85, 87, 94) the marketing perspective is almost totally absent and may in fact have been buried altogether by the change in strategy from product advocacy to change process advocacy. A distribution system for other than conventional commercial products is also lacking. The manner in which the emerging dissemination network may become (or become linked to) a distribution system is still unclear.

5. The Future

At the present point in time, the linkage functions of marketing/distribution/dissemination/diffusion, must be assessed as underdeveloped and weak in their impact on the user system. If they are to be strengthened, collaborative federal/state/local and private/public initiatives will be needed, designed specifically to take into account the essential requirements of the dissemination/linkage functions and the current state of development of these functions in the field of education. As a basis for suggesting key needs, we will review our understandings of its assessment basis and current status. In our discussion here, we will focus on dissemination.

Assessment Basis

The function of dissemination is critical to the entire R/D&I system. It is, in essence, a linkage process which "connects" knowledge producers with knowledge users. Thus, as we have been implying, the R/D&I dissemination system must provide for mechanisms which: can determine what is available; can sort out the "good" from the "bad"; will allow users to identify and obtain the particular products which are relevant to their needs; as needed, can "tailor" products to fit user needs; can motivate users to "try" a product; insures effective user implementation and utilization.

Assessment, then, must be made in terms of capacity to achieve and success in each of the above requirements. Overall we would wish to know this with respect to:

1. Extent and quality of "reach" into user systems (e.g.: number being reached, the extent of repeat utilization of dissemination services, and user satisfaction with such service).
2. Levels of user awareness and trial of R&D products (existence, character, and evaluative) .
3. Contribution to implementation and utilization of R&D products. Since this depends on such other factors as number and quality of products available, user skills and receptivity, etc., the dissemination function can only be assessed as a contributor to the process. This must of necessity be a qualitative evaluation.
4. The existence of a well developed and cooperative network of dissemination mechanisms giving coverage across the nation and to the variety of users to be found.

Current Status

In education, we find a number of problems and barriers to dissemination. There are an enormous number of users (some 17,000 school districts - - plus teachers, etc.), among whom there is wide diversity and variety as to philosophy, interests, perceived needs, etc. Innovations make demands on the time of school personnel (a very practical matter) and generally require "people change" - - factors which can lead to resistance to innovation. Additionally, at least two major factors have tended to create a very poor climate for dissemination in education: (1) a lack of implementation/utilization support to the user; and (2) the perception that the outputs of the (for the most part) newly created R&D system have generally been inferior to existing user-developed products.

In education, there has been a considerable amount of activity that has been called dissemination, and a large number and variety of organizations are involved in some kind of dissemination - - but much of this has been fragmented and scattered (e.g.: "add-ons" to development projects; successful but separate and discrete dissemination systems for specific categorical programs). As yet, however, there is relatively little coordination of federal, state and local resources nationwide, and no systematic way of tapping into the whole nationwide resource base. Further, there is not yet a well developed personnel base of trained dissemination specialists. Several federally funded programs have been developed in recent years for training dissemination and utilization specialists, but dissemination mechanisms are expanding far more rapidly and creating a far greater demand for trained personnel than these programs could even hope to keep up with.

Key Needs

From an overview perspective, then, the need is for:

1. orchestration of educational R/D&I dissemination from a total system perspective;

2. in the short term, facilitating the work of existing dissemination mechanisms and "filling" critical "gaps";

3. in the long term, providing for overall system building (this calls for policies and strategies which are proactive, not passive or reactive, and which are based on a knowledge of what does and does not in fact exist); and

4. balancing short and long term needs.

More specifically, policies and strategies federal funding agencies will need to be developed in collaboration with the states to focus upon:

1. quality control;

2. mechanisms that can optimize product/dissemination/user "fits";

3. providing users with alternative channels of access to the available resource base (a "mixed strategy" approach).

Keeping in mind the limited level and rate at which users can absorb new input once a dissemination system is established (a factor which is of critical importance), dissemination policy will need either to expand the dissemination technical assistance capability or slow the rate of dissemination system expansion. To achieve a balanced and appropriate growth rate, ongoing monitoring of the dissemination function will be essential.

XV. ACQUISITION

The weakness of the dissemination/linkage functions and their minimal impact on the user system become particularly evident from examination of the acquisition process in the user system, and the problems faced by user personnel in learning about and acquiring externally developed R&D outputs.

1. A Virtually Non-Existent Function

The acquisition function is virtually non-existent in education as an institutionalized activity. The purchasing specialty that one sees in industry is either totally lacking in education or (where it does exist) tends to be highly restricted in scope to little more than handling the paper work of purchase orders and invoices. Search, product evaluation and assessment of bids are confined to purchases of conventional supplies and equipment - - e.g.: paper, crayons, and chalk rather than textbooks, new curricula, or instructional systems.

2. Causes and Effects of Acquisition Weaknesses

The weaknesses of acquisition processes in education are a consequence of two conditions:

1. The marketing/distribution/dissemination/diffusion systems in education have been so inadequately developed, so diffuse in structure and so uncoordinated in channels that the educational marketplace is chaotic in nature.

2. There is a general absence of specialized resources allocated to the acquisition function.

A. Difficulties Facing User System Personnel

Thus, user system personnel face great difficulty in learning about or evaluating the alternative programs or products on the market to meet a given need. There is no systematic mechanism to link potential users to available suppliers, or even to inform the potential user about who these suppliers are or what programs or products they have to offer.

Individual development organizations provide catalogues of their own outputs, but there are few comprehensive guides. Even those few which were intended to provide comprehensive coverage of the outputs of a given set of institutions (30) or the outputs produced under funding from specific agencies (84) or outputs oriented toward specific areas of practioners' needs (41) tend to provide less than complete coverage, or information in a form less useful than needed.

B. Absence of Evaluative Information

Perhaps most critical of all, there are few gatekeeping quality control mechanisms to screen out weak innovations and there is little evaluative information about available products and practices. There have been some recent initiatives to provide validity/quality control mechanisms on the federal and state levels (e.g.: the federal Joint Dissemination Review Panel established to validate selected educational R/D&I outputs, and state programs set up to validate "exemplary practices"). However, these have been too limited to have significant impact. In the absence of well established widely used bases for rational decision making about whether or not to replace existing practices or materials with new products or R&D outputs, faddism has been characteristic of school system adoption of educational innovation. Even where evaluative information about a product is made available to potential users, validated products of this kind are competing with a large volume of nonvalidated products and practices. (74) Thus, it is still difficult for the potential user to make a rational choice among alternatives.

3. An NIE Response

NIE has recently begun funding programs designed to provide uniform, comparative evaluative information across the whole range of products and practices available to meet a given need (e.g.: the 1976 Catalogue of NIE Education Products; the product information packages accessed in ERIC; and NIE's Consumer Information Program). It will take some time before we will be in a position to assess whether this new strategy has been effective in providing some order to the educational marketplace and needed supports for the acquisition function.

If this strategy is to have as much impact as possible, the target of the strategy within the user system will need to be narrowed. At present, the acquisition entry points are scattered throughout the system. The awareness, interest, information search, etc. that bring a new product or innovation into the acquisition decision process may begin with teachers, principals, curriculum specialists, the Superintendent or members of his staff, or even parents or community residents -- virtually anyone in the system or its environment. This can be a source of strength for the acquisition function. At present, however, it is relatively rare to find anyone *responsible* for initiating and carrying out acquisition activities as a major part of his job. Therefore the process remains episodic, haphazard, and random -- not well integrated into system functioning and long range planning.

There is suggestive evidence that the most innovative school districts may be those that are best linked to the external resource system -- either because of the professionalism of the teaching staff; or the leadership orientations and style of the principals or Superintendent; or the presence of external change agents; or especially the existence of curriculum specialists or coordinators on the staff who devote time and attention to determining what materials and products are available for acquisition.(4, 9, 73) Therefore, initiatives to improve the efficiency and effectiveness of the acquisition function by providing more and better linkages to the external resource system would appear to be a potentially potent strategy. These linkages could be developed either by providing more specialized personnel responsible within the system for stimulating and coordinating acquisition activities; or by providing materials or technical assistance personnel to provide this stimulation and coordination from outside the system.

The latter strategy is at the core of NIE's new Consumer Information and R&D Utilization programs. Together, they propose to: (1) provide targetted materials designed to inform practitioners about what existing theory and empirical research suggest about specific problem areas; how this relates to existing and exemplary practices; and what R&D products and programs are available to meet given needs; and (2) provide technical assistance personnel to help schools select, adapt, install, and utilize available products and practices to meet their needs.(83, 89, 91) If these programs are effective and widespread in impact, the acquisition function will be strengthened and significant gains will have been made toward achieving the R/D&I system goal of improving educational practice. At present, however, the acquisition function remains random and episodic, and its impact on school system functioning is limited at best.

XVI. IMPLEMENTATION AND UTILIZATION

1. A Neglected Function

Implementation/utilization has been one of the least understood and most neglected of the R/D&I functional specialties in education -- diffusion research generally ended at the point adoption decisions were made by school officials, thereby ignoring the implementation/utilization stages of innovation.

The study of implementation/utilization was spurred by the contradiction between research results that showed high levels of innovation as measured by adoption decisions but low levels of innovation when classroom practices were observed. As researchers began to examine what happened to innovations after the adoption stage, they discovered that innovations were in fact not implemented at all; or were transformed during implementation into "more of the same old thing"; or were terminated as ineffective within only a few years. The failure of innovations to survive the installation and trial periods was traced to two rather different kinds of problems:

1. on the one hand, resistance to the innovations by operating personnel because of attitudes, norms, and user system constraints;

2. on the other hand, technical complexities and difficulties requiring capabilities beyond those of operating personnel (in the absence of implementation supports that were rarely provided).(52, 119)

2. The Knowledge Base

There is an extensive knowledge base about user system norms, values, and various kinds of constraints that make teachers, principals, and other operating personnel resist certain kinds of innovations.(26, 27, 114, 119, 125) Far less is known about the technical problems and the kinds of implementation supports needed to overcome these problems -- or how to identify potential technical problems; assess user personnel capabilities in relation to these technical problems; and design training programs, technical assistance roles, and other required implementation supports. However, there is suggestive evidence that the technical problems may be of far greater significance for determining the fate of an innovation than attitudinal problems. More practice-based research and systematic evaluation of implementation support strategies will be needed to develop an adequate knowledge base to permit efficient and effective attack on the technical problems of innovation implementation in education.

3. Emergence of Linkage Organizations

A number of types of linkage organizations supporting the implementation process have been emerging in the education sector in recent years. We would include here: external groups such as training organizations, technical assistance groups and various types of educational consulting firms; internal organizational units where they exist (e.g.: a school district's teacher trainers, OD and renewal teams, etc.); and especially the state and interstate networks of school service organizations that have been promoted by recent state and federal initiatives.(91)

The implementation support strategies used by these organizations appear to lean more heavily toward a clinical change model of working with clients to adapt innovations to local circumstances -- as contrasted with the R&D delivery model of assisting school districts in acquiring standardized products developed by R&D organizations. However, beyond this general orientation suggested by the literature, we know very little about the nature or scope of this institutional base: how many organizations there are, and of what various types; how they are distributed geographically and by services provided; how many school districts they serve; what strategies they use and with what degrees of effectiveness; what personnel bases and other resources they draw on; the nature of their linkages with KP as well as KU, or with other linkage organizations; etc.

4. NIE

The state and interstate networks have been given increased visibility and some increased support from NIE's sponsorship of its R&D Utilization program. State networks of regional intermediate service agencies have been developed in approximately 25 states, and some other states have developed implementation support programs using other organizational arrangements. Interstate networks of various kinds have also been organized to link schools and districts dealing with similar problems or using similar innovative approaches (e.g.: ES '70 Schools; the Network of Innovative Schools; and the RBS network of schools using Individually Prescribed Instruction). The NIE R&D Utilization program described in a recent NIE RFP will fund selected proejcts organized into four configurations of implementation support agencies:

1. state organized systems of intermediate service agencies;
2. state systems not using intermediate service agencies;
3. interstate consortia of schools organized as groups of users;
4. interstate consortia of agencies primarily devoted to producing R&D outcomes and/or delivering technical assistance.(91)

By specifying the type of organization that will be supported, this project is likely to stimulate the development of this kind of networking as well as provide support for already functioning networks. The data assembled from this program and NIE's KPU monitoring program are likely to increase our understanding of the institutional bases that exist for conduct of the implementation/utilization support function; what proportion of the approximately 17,000 school districts in this country are served by these organizations; the activities that define this function in the education sector; and perhaps also the relative effectiveness of different implementation support strategies. At present, there is little in the literature to provide a clear picture of the nature and extent of the implementation/utilization support function as it exists today in the education sector.

XVII. SUPPORT SERVICES

1. Changes in Support System Patterns

As educational research and R&D activities have expanded in scale, the traditional research pattern of the individual scholar working relatively alone in his study or his laboratory has been replaced by team research under complex organizational and inter-organizational arrangements, supported by a complex subordinate system of mostly sector-spanning private corporations providing services and supplying and maintaining equipment.

Included in this support system are the traditional research support services -- e.g.: research libraries and suppliers and maintainers of the equipment used in the laboratories. Also included, however, are suppliers and maintainers of the kinds of equipment and services that distinguish the newer, larger-scale research and R&D from the older, smaller-scale research and R&D pattern -- e.g.: computer centers, data processing service bureaus, and computer maintenance services; the suppliers and maintainers of calculators, photocopiers, typewriters and other office equipment and of the various kinds of audiovisual hardware that are becoming so prominent in instructional system development; the film laboratories, videotape editing facilities, cassette reproduction laboratories, and printing and publishing facilities that play such important support roles in the production of materials and complex multi-media instructional systems; survey research service organizations that play a dual role both as R/D&I performers on projects of their own and as suppliers of support services for other R/D&I organizations; and the various mechanisms and arrangements that exist to protect proprietary rights for R&D outputs that are not clearly in the public domain. Included too, especially for the larger and more complex projects, are secretarial and clerical services, generally but not always provided internally.

2. An Inadequate Knowledge Base for the Support Service Function

There is relatively little in the published literature about the subordinate system of support services for educational R/D&I. We assume that there is a great deal of information in the files of federal agencies and R/D&I organizations that would be useful for assessing the scale, distribution, organizational capabilities, and client service patterns of the various support systems; the relative cost-effectiveness of the in-house vs. external strategies for supplying different support services (e.g.: data processing or survey research units) for different purposes in different types of organizational settings; and the strengths and weaknesses of various kinds of procurement arrangements that are used. Transfer of support system management strategies from other sectors might be accomplished with relative ease once the configuration, dimensions, and service patterns of the support system for educational R/D&I are clarified and related to those contextual conditions that function as constraints on the procurement and provision of support services for the educational R/D&I system. However, without such basic information, we are not in a position to attempt to transfer successful strategies from other sectors to the education sector.

XVIII. EVALUATION RESEARCH

1. Historical Context

Of all the R/D&I functions in the education sector, evaluation research has experienced the most rapid and extensive development in the last ten to twelve years.

Prior to the mid-'60s, evaluation of educational programs (when it was done at all) was carried out by educational practitioners and by some researchers -- but rarely by people who identified themselves as evaluation research specialists. The approaches tended to be normative, but rarely systematic or rigorous. The predominant strategy was casual observation and analysis. Conclusions tended to be based on expert opinion, intuition, and impression rather than systematically gathered and rigorously analyzed empirical data.

This pattern changed significantly in the '60s as large-scale federally funded social programs proliferated, and the legislation that created them tended to require the systematic gathering, analysis, and reporting of empirical data on program effectiveness. Thus, the evaluation research function expanded rapidly as a new specialty, even as a new industry: in less than a decade DHEW and Department of Labor evaluation contracts expanded from a $5 million to a nearly $50 million industry.(43) 1971 data for DHEW evaluation contracts indicate that 74% of these funds went to non-profit and for-profit research corporations, and only 21% to universities or university-affiliated organizations.(1) Many of the research corporations are sector-spanning institutions, bidding on evaluation contracts in education, health, personnel base development, social welfare, and (in the case of some of the more diversified research organizations and management consulting firms) industry, defense, and aerospace as well.

The expansion and maturation of the evaluation research function in education must be viewed as part of this broader development of the field of social program evaluation -- showing the same large increases in numbers of evaluators and amounts of evaluation activity; the same growing influence of research corporations competing with universities for evaluation contracts; and the same kinds of attention to methodological, organizational, and political issues inherent in the evaluation role.

2. Methodological Issues

During the '60s and early '70s, there were many heated debates among evaluation and research theorists about appropriate methodologies for the evaluation research function. One group argued that experimental (or quasi-experimental) designs were more powerful than any other research approaches for assessing the effectiveness of programs, products, or strategies -- and that it was therefore essential to use these approaches to test R&D outputs and to reform programs of all kinds.(10) A second group argued that experimental approaches imposed unrealistic constraints on field settings -- and that at any rate it could never be possible to meet adequately the statistical, design, and treatment assumptions on which experimental approaches are premised.(53, 135)

Other methodological debates revolved around the need for evaluation approaches to provide feedback throughout the program development process -- not simply telling the developer at the end of the development process that his program did not work, but working with him throughout the process to make it better.(121) Existing pre-post evaluation designs made it difficult for program evaluators to provide this kind of feedback, or to understand how to evaluate a program stimulus that kept changing.

Some of these disagreements have been eased by recognition among evaluation researchers that there are a number of different kinds of evaluation services, each requiring somewhat different approaches and techniques. The distinction between formative and summative evaluations represents one such difference Initially, the same researchers conducted both formative and summative evaluations, but over time there appears to have been some specialization of personnel and organizational units here.

Currently, the formative evaluations that are undertaken as part of the R&D program/product development process are generally carried out by evaluators who work with developers as part of the development team and provide ongoing feedback designed to improve the product or program being developed. They use both quantitative data-based and qualitative judgmental approaches. Their style of functioning emphasizes flexibility -- changing their research questions, variables, instruments, and approaches as the emerging program takes shape and perhaps goes through a number of transformations.

The debate over experimental vs. other kinds of research designs is now centered on summative evaluations -- the evaluations undertaken to test the effectiveness of a given program or product after it has been fully developed. Summative evaluations are usually done by an evaluation agency or organizational unit independent of the program's developers. Summative evaluations include several types of evaluations differing somewhat in emphases because of the different information needs of the decision makers to whom they are addressed:

1. final operational field tests of an R&D output to help the R/D&I manager determine whether or not it is ready for dissemination;

2. evaluations of the effectiveness of a given program or product in a given school or district in meeting locally defined objectives;

3. evaluations of national program initiatives, sampling program components nationwide to inform federal policymakers about the effectiveness of a given strategy (or the relative effectiveness of alternative strategies) in meeting federally defined policy goals.

There is still some disagreement about how appropriate experimental designs may be for product tests and for individual school or school district program evaluations; and many other kinds of research designs have been proposed for these types of evaluations. Nonetheless, a federal program evaluation policy (to whatever extent such a policy exists) appears to be moving toward experimental approaches -- increasing numbers of national program evaluations are being conducted using experimental designs, control groups, and some randomization of treatments.(43) However, the difference between experimental setting in the laboratory and the field is gaining recognition. Federal evaluators are increasingly acknowledging the need to supplement impact data with process data demonstrating that a given "treatment" was in fact implemented as specified in the program design, and that the impact evaluation is a valid test of the program and not simply a "non-event." (13) Otherwise, questions can readily be raised as to whether a program evaluated as a failure was in fact a failure - - or whether instead it was never even tried (and thus what was evaluated and judged a "failure" did not in reality even resemble the specified program "treatment").

3. Organizational and Political Dilemmas

A. The Evaluator's Role

The evaluator's role has come to be understood primarily as one of meeting the information needs of decision makers.(134, 135) However, there are a number of issues and problems involved in this assumption. For example:

> Which decision makers are we talking about: implementation personnel? program managers at specific sites? program managers at the local, state and/or federal level? policy makers (and at what level)?
>
> How does the evaluator deal with the difficulty decision makers have in defining their information needs; in agreeing on what information is relevant or in agreeing on what measurement procedures and instruments are valid?
>
> How much input can an evaluator have in defining what he investigates? Must he accept the client's definition of the program's objectives and simply assess the effectiveness of the program in meeting these objectives? Or can he include in his evaluation consideration of the appropriateness of these objectives (or the program's rationale or strategy) for meeting the ultimate goal of the program's developers?

B. The Political Dilemma

Evaluations are often described as management tools designed to provide a "rational basis for decision making" -- but decision makers in the public sector function in a largely political sphere. This fact raises important issues for the evaluator on both theoretical and practical levels.

On the theoretical level, we must ask if political considerations are "irrational," or if they are based on "a different model of rationality" from the one generally used by social scientists.(146)

On the practical level, consideration must be given to the politics of decision making. Generally speaking, programs are created by political coalitions of diverse interests -- interests which support programs for diverse reasons. These coalitions tend to view negative evaluation research findings unfavorably -- and generally have enough influence to modify or bury negative findings and keep their programs going regardless of what evaluators report. Conversely (yet similarly), programs may be opposed by other political interest groups -- interest groups who will use findings of evaluation research to achieve their ends. Thus, evaluation research findings may be used, misused, modified, reinterpreted, buried, etc.(21, 145, 146) -- in other words, used as a "political football". Given the political context and the methodological issues we have noted above, it is not surprising that controversy over negative evaluation research findings are so often phrased in terms of methodological issues rather than evaluation findings per se.

C. The "Value" Dilemma

The educational context is value-laden, and value choices enter virtually every one of the key decisions made by the evaluator. The outcome of evaluation research may be predetermined by the choice of research questions and objectives, the criteria used in judging effectiveness, or the measurement instruments administered. From the human perspective, the question must be asked: Is the evaluator value-free when doing evaluation research? From the organizational/political context perspective, the question must be asked: To what extent is/should these key value decision choices of the evaluator be influenced by the organizational information needs of the decision maker on the one hand, and the political context/dynamics on the other hand?

D. Current Trends

Evaluators are developing an increasing sensitivity to the politics of decision making. The evaluation research literature has shown the progress made by the field over time in coping with this situation -- from an early literature that simply bemoaned this situation, to more recent writings that accept it as a given and build consideration of the politics of decision making into the planning and implementation of evaluations to make them more "strategically useful ". (7[illegible], 146)

The evaluation research function is in a much stronger organizational and political position now than it was a decade ago. Instead of being located in marginal units that could be easily ignored, planning and evaluation units and their administrators are now included in the top management decision structures of federal agencies. (43) The evaluation research function is taking on increasing prominence in the General Accounting Office's auditing activities. (131) On the state level, legislative oversight committees with strong evaluation research staffs of their own have given significant visibility to evaluation research activities and findings. (80)

4. The Impact of Evaluation Research in the Education Sector

There is still substantial disagreement over just how much impact the evaluation research function has had (or can have) -- but clearly, there is relatively little evidence of extensive use of evaluation research findings as the basis of policy decisions. Equally clearly, relatively few high quality evaluations have been produced and even the better evaluations have suffered from serious methodological flaws. The field of evaluation research lacks an adequate theoretical base, and is even more lacking in adequate instrumentation. There is no clear federal evaluation research policy, and federal agencies have not even issued guidelines as to what constitutes an adequate or appropriate evaluation. (OE, though, has been moving in this direction and beyond for the evaluation of ESEA Title I programs).(64, 104, 106, 136) It would seem, then, that the evaluation research function in the federally funded social program field remains weak in comparison to the evaluation research function in mature R/D&I systems.

XIX. RESEARCH ON R/D&I

1. Availability of Analysis and Empirical Research

Given the relatively brief history of educational R/D&I, there is an astonishingly large accumulation of analyses and empirical research on the functioning of the system. This is attributable in part to the negative political climate in which the system functions -- the lack of confidence in Congress and various federal agencies in the educational R/D&I enterprise. As noted earlier, there has been a tendency to pull the system out by its roots every couple of years to see how well it is growing and to determine how its effectiveness might be improved. A large number of these analyses were conducted by or for federal agencies or Congressional committees.(36, 105, 107, 117, 130)

A second factor of some importance in accounting for the large number of analyses was the increasing self-consciousness of the social sciences in the late '60s as to their proper role in relation to governmental agencies and the utilization of social science knowledge. Some of the relevant literature was provided by study committees of the National Academy of Sciences - National Research Council; the National Science Board; the National Academy of Education; and the President's Science Advisory Committee.(8, 34, 81, 82)

Some of the relevant literature is traceable to an international stimulus -- a request from the Organization for Economic Cooperation and Development (OECD) for OE to participate in a cross-national review of educational R&D and an analysis of how R&D might be strengthened to increase its potential for improving educational practice.(73, 109)

Some of the more recent literature is the result of the emergence of knowledge production/utilization as a new research area in the educational research community.(123)

But probably the most important impetus of all in recent years has come from the sponsors of educational R/D&I (not only OE and NIE but also private foundations such as Russell Sage) -- e.g.: their increasing interest in evaluation research as a basis for policy formation;(11, 45) their initiatives to support the design, development, and utilization of routinely collected data bases for monitoring the progress of the educational KPU system, detecting problems, and determining the impact of policy initiatives.(37, 71, 92, 95, 122)

2. Types of Studies in the Literature

The literature can be categorized into five types of studies:

1. distillations of expert analysis and opinion;
2. systematic empirical evaluations of particular components or outputs of the educational R/D&I system;
3. syntheses of the relevant literature;
4. case studies of exemplary educational R/D&I projects; and
5. descriptions of the KPU data base and monitoring system that is being developed under NIE auspices.

Most of the relevant literature (and virtually all of it that was produced during the first five or six years of the federally funded system's history) falls into the "distillation of expert analysis and opinion" category. These analyses were generally based on interviews; site visits; examination of materials in agency files; perusal of system outputs; or the insight of scholars working together to form judgments and make recommendations.(2, 3, 14, 15, 16)

Systematic empirical investigations make up the second largest category -- e.g.: evaluations of personnel training programs;(124) or ERIC information products;(46, 143) or pilot state dissemination projects;(67, 127, 129, 141) or AERA meetings and journal publications as critical elements in the KP information flow system in education;(99, 101) etc.

We include here especially several studies of the evaluation research function -- how it is organized; who does what kinds of evaluations with what degree of effectiveness; how evaluation findings are used; etc.(1, 6, 45) The "research-on-research" character of these studies of the evaluation research function suggests a particularly high level of self-awareness within this function.

There are relatively few documents in the other three categories. The literature that is available clearly reflects the institutionalization of "research-on-research" in educational R/D&I -- efforts to synthesize the existing literature;(93, 103, 115) efforts to map the domain of educational R/D&I;(18, 35, 115) and descriptions of NIE's KPU monitoring project designed to: develop a data base on educational KPU functioning; use the data base to build models of the dynamics of KPU functioning in education; and monitor KPU functioning to identify problems requiring new policy initiatives or to assess the effects of existing policies and policy changes.(92, 95)

At present, the research literature on educational R/D&I functioning touches on only limited areas of system functioning; provides relatively little empirical data; is atheoretical; and appears to be only minimally utilized by either sponsors or performers of R/D&I activity. However, all of this may change if the NIE monitoring project is effective in institutionalizing research on the educational R/D&I system and providing the kind of data base and policy analyses suggested in current project descriptions.

XX. CONCLUSION

We have throughout this report noted weaknesses in the educational R/D&I system. It is important now to re-emphasize that we have also noted that what we have found would be generally what one would expect to have found within a relatively young R/D&I system. There has been progress, and there are signs of the beginnings of a transition from the introductory stages of system development.

Thus, as we noted at the outset, the current state of the educational R/D&I system must be assessed in terms of where it has been and where it now has the potential to go - - not in terms of unrealistic expectations about "progress and output to date".

With this perspective in mind, we can see the last two decades as a period of some important achievements in the creating and building of the educational R/D&I system in the United States. As compared to twenty years ago:

1. There are today some 1500-3000 organizations (academic, private, and public) which have R/D&I capacity - - most of this capacity being relatively new and being largely the result of federal funding.

2. The personnel base has doubled (perhaps tripled) - - from around 4000 in 1969 to 8-12,000 in 1974. Most of this work force is represented by research and development personnel.

3. The educational R/D&I system has produced a substantial number of outputs. Some of these have been outstanding quality and of a widely reported excellence - - products from R&D organizations and exemplary products which have been identified, generalized and widely disseminated.

4. Some linkages have been developed between some of the strong development organizations and the school systems who have been using their products.

5. Since some degree of maturity of a knowledge/technology base is necessary to allow its codification into handbooks and other syntheses, we may infer some beginnings of educational R/D&I system maturity from the increasing level of availability of such handbooks/syntheses.

As the R/D&I system has matured, inevitably some of the functions have developed and/or been supported more than others. It will be important to maintain a "balance" between these various functions of the educational R/D&I system. This balance must take into account for each function:

1. the time period needed to produce significant outputs;

2. the impact each function has on the other functions;

3. the level of funding needed both to maintain a balance and to maintain the basic integrity of the personnel and institutional base within each function.

4. what currently does/does not exist within each function (in terms of outputs and of the institutional personnel, knowledge and technology bases).

In summary, the period of the last two decades has been an important era of initial system building for the educational R/D&I system. There remain problems, weaknesses, critical gaps to be filled, balances to be achieved -- as one would expect to find in a relatively young R/D&I system. These identified needs become the focus for system building and rebuilding for the next transitional phase for the next five to ten years. In this period, it will be vital to provide continuity, stability and security in order that the educational R/D&I system can take root, grow and develop maturity. Only in these ways can we hope to develop a maturing educational R/D&I system which can have significant impact on the educational system in the United States.

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CHAPTER FOUR

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Figure 1 -- Partial Model of Main Institutions in the Aviation R/D&I System

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Since 1959 the term "aerospace industry" has been used to denote the industrial sector serving both space and aircraft development and production. Space work has been almost entirely devoted to serving the federal civilian and military exploration programs, while aircraft manufacturing serves both military and commercial users. For our purposes, discussion of the space and military aircraft cases would involve issues of lesser interest (given the specific nature and requirements of the users) than the case of the civilian aircraft industry, although, as will be seen, it is not possible to completely separate these subsectors. Therefore, the primary focus of our contextual analysis will be set within the civilian aviation industry.

I. ENVIRONMENTS OF THE R/D&I SYSTEM

1. Political Conditions

A. Federal Funding

Federal funds going into industrial R&D in the aerospace industry have tended to exceed company funds in the ratio of about 5 to 1 (DOT (13)). As we noted above, each of the significant stages of development in aircraft technology between 1926 to 1971 were preceded by periods of government funded R&D. On top of this, it is federal money that supports the work of NASA, the source of most of the basic research in the field. Not surprisingly therefore it has been in the Congress and in the Executive branch (including at NASA itself) that much of the decision making on the rate and direction of equipment R&D has been made. Additionally the roles of FAA and DOT have been significant in the determination of airline policies and procedures, and in turn, on policies and procedures of the manufacturers of airline system products. Whether we are referring to prices, schedules, safety, flight patterns, maintenance requirements etc., it must be remembered that the airlines industry is highly regulated.

B. International Relations

Another important political aspect is the role that aviation plays in international relations. Having a major airline has long been a matter of national prestige. Even small countries that can ill afford the investment support their own flag carriers (even at substantial loss in revenue) for reasons of prestige or for security (as might be claimed, for example, by Israel*).

---

*Although El Al does not in fact represent such a drain on that economy.

Equally (or more) important has been the fact that most of the free world flies in American made equipment, this time with economic as well as political implications. The Anglo-French Concorde project is at least as much a political as an economic venture. In fact it is probable that flights of these planes will need to be (and will be) highly subsidized by their respective governments to help establish them in the marketplace. The present political battle over landing rights for the Concorde has been said to have major implications for U.S. relations with Britain and France. Also, considerable concern exists over the possibilities of the U.S.S.R. becoming a source of aviation equipment.

2. Social Conditions

This has all been taking place during a period in which social acceptance of airline travel has become established. During a period of approximately 25 years revenue passenger miles has increased an average rate of about 13% per annum, rising to 20% or more in some years(11). Over the period of the last twenty years both total world and U.S. airlines have experienced an approximately twentyfold growth, and estimates for the 1976-85 period are for 50 billion dollars (worldwide) of commercial aircraft deliveries (at constant 1974 dollars), almost as much as in the previous 25 years(13).

The enormous and growing demand for the service and the product (coupled with the tremendous rate of change of the technology) indicated a user population that was "pulling" new R/D&I outputs in a most intensive manner -- although Schiffel (29) believes that traffic growth acts as a "permissive" factor rather than as a cause of aircraft technological innovation and acquisition by airlines. The fact is that the use of the airplane as a means of passenger and cargo transportation is established; and there is a pattern of expectations for continual improvement in service (allowing for the effects of fuel crises, etc.), even though demand may now have stabilized.

3. Economic Factors

A. Federal Expenditures

Changing patterns of federal expenditures on space and defense have had enormous impact on the aerospace industry. The industry has a reputation of feast and famine conditions, with major layoffs and rehiring of even the most qualified personnel being common. The federal bail-out of the Lockheed Corporation is a well known event.

As we stated above, federal funding for aeronautics R&D has been substantial. During the nine years of 1967-75, approximately seventeen billion dollars was spent by the federal government, with nearly two billion of this in NASA. Further, the trend has been up -- approximately 50% over the overall period, and almost tripled at NASA (reflecting a shift back from space to aeronautics R&D). Such a level of support can hardly be ignored.

B. The Technological - Economic Interaction

It is also a fact that it is difficult to understand the technological and R/D&I system issues in the aviation industry without an appreciation of the effect which economic forces and structures have on the producers of aircraft and their airline industry users. Let us examine this interplay of these techno-economic relationships.

1. Airlines

Airlines are oligopolies, highly regulated in the U.S. by the Civil Aeronautics Board (CAB). Fare competition is virtually non-existent both for major national airlines and in the international contest (under IATA control).

Two-thirds of the investment of airlines is devoted to purchase of aircraft.* Given industry-wide price controls, competition is transferred to service, image and operating cost differentials. To a considerable degree, as Schiffel (29) and Gellman (14) recognized, the acquisition of new aircraft by airlines becomes a competitive device -- and as we would note, a defensive strategy (you can't afford to be using obsolete equipment at the same ticket price for less service). This strategy has been made possible by the continuing pattern of increasing demand (traffic), at least up to recent times.

2. Aircraft Producers

Aircraft producers (essentially the airframe manufacturers) are, by now, also members of a highly concentrated oligopoly, with only three major manufacturers (Boeing, McDonnell Douglas and Lockheed) left in the U.S. industry (which in practice represents most of the non-communist world's civilian aircraft capacity). Other firms such as Convair and Martin have been forced out of the competition, with ever-growing tooling costs demanding long production runs and hence concentration permitting economies of scale.

Demand for new aircraft, while growing at a substantial rate, is not easily or quickly expanded beyond this pattern. The limited number of major airlines seek to minimize the variety of aircraft they use for a specific application (e.g.: long vs. short haul) in order to keep down operating and maintenance costs. Aircraft have relatively short first-line life cycles# because of rapid rates of change in technological opportunity (frequently deriving from technology transfer from the military sphere).

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* Recent trends towards leasing aircraft from equipment trust funds may be helping airlines to alleviate this major financing problem.

Although equipment may be kept on for less competitive applications for 15-25 years, and even longer in the aftermarket.

The previously mentioned shift to service differentials (as opposed to price) as the arena for airline competition creates an enormous incentive for producers to be on the market with new products first -- or not far behind. Because diffusion rates for adoption across the airline industry is rapid, airlines must commit themselves early to a new range of equipment -- and the latecoming producer is squeezed out. The consequence has been fierce technological competition between manufacturers. Further, unlike certain other fields, it is virtually impossible to play the role of a technological follower who substitutes marketing "clout" for technological innovation. The performance characteristics (speed, range, capacity, noise, operating cost per mile, etc.) are too clear and quantifiable across most criteria to permit manipulation of a sophisticated customer, the airlines.

3. Other Economic Factors

Recent public concerns with environmental effects (noise pollution, etc.) may act to herald in a new wave product innovation that the airlines will not be able to resist, despite the negative economic implications that this would have on them.

The changing economics of fuel may force the introduction of more economical equipment. Thus, for example, the airlines and airframe manufacturers have in the past shown little interest in the NASA super-critical wing technology that could promise a few percentage points of improvement in flight performance (and hence reduce fuel utilization). The arena for cost reduction as the airlines saw it lay in the total cost of operations more than in flight costs. While this still may be true, the sharp jump in aviation fuel prices has led to an upsurge of interest in this new technology.

Another important consideration has been the substantial role of aviation exports (civilian and military) as a factor in the U.S. balance of payments, and the increasing threat of foreign competition. In 1971 aerospace exports surpassed 4 billion dollars. Brizendine (8) estimated that 93% by value of the free world's civil transport came from the U.S. The ten year forecast for the total market is over 50 billion dollars.* In such an environment R&D must and does receive a high priority.

4. Scientific and Technological Conditions

A. A Well Developed Scientific and Technological Field

While the history that we have presented spans only seventy years, the scientific roots of some of the central disciplines can be traced back to the contributions of Leonardo da Vinci, Gallileo, and Newton, with later work by Leonhard Euler and Daniel Bernoulli in aerodynamics.

Modern aerodynamics dates from the turn of the last century with the work of Lanchester in England; Kutta, Von Karman and Prandtl in Germany; and Zhukovski in Russia. In the years since, the field, with its associated fields of structures and materials, has become a highly developed, scientific and engineering based specialty, with substantial experimental facilities such as wind tunnels being constructed. Aero engines date from 1851 (by the Frenchman Giffard, applied to airships) and from the work of the Wrights and Manly in 1903, with continued and accelerating developments through the second world war. The work of Whittle and others starting in 1939 in England and Germany ushered in the jet age in the mid-1940's.

In the internal combustion and jet engine technologies, we are by now dealing with a very well understood and documented field, amenable to classical processes of scientific and engineering improvement. The advances in aeronautical electronics are more recent but fall into the same pattern, with especially rapid advances in recent years with the progress of the field at large. All together the subfields can generally be seen as highly specialized, scientifically and engineering based, and highly codified. Standards are a way of life for every detail and feature.

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*It is to be noted, however, that return on sales in the aerospace industry has tended to be around 2.5 to 3.0% compared with about 4.5-5.5% for all manufacturing firms, although return on stockholders equity is about the same (DOT,(13) p. 68).

An exception to the above pattern is the more recent concern with human factors and use characteristics. In these areas (e.g.: as these might relate to cockpit and controls designs to provide high effectiveness, low fatigue, etc.) and in the areas of passenger facilities designs, etc., less developed areas of knowledge are being used. Similar problems arise in considerations of the man-machine system aspects of flight, command and control, safety, etc.

B. Innovations: Abrupt or Cumulative?

We would be remiss in our discussion if we lead the reader to conclude that there is a continuing flow of radical and large scale innovations stemming from fundamental (i.e., "breakthrough") changes in the state of the art leading rather abruptly and automatically into major new applications. There have been (and continue to be) considerable and continual advances in components and materials, some traceable to fundamental advances; and these surface, from time to time, in new aircraft configurations and models having radically upgraded characteristics. But it could also be claimed that there have been no really radical innovations in aircraft from the time of the first jet planes up to the recent NASA developed super-critical wing technology. It can be claimed that what we have seen has been a series of cumulative (though very significant) improvements. This is a perspective that is open to much debate, but it is congruent with the view expressed by Abernathy and Wayne (1) in their discussion of the "learning curve." Regardless of which viewpoint is "correct", we should note that the net result of innovative activity in DOD, NASA and industry has been a very significant trend of performance improvement over the last few decades.

C. The Technological Imperative vs. User Needs

The importance of technology transfer from military to civilian aviation has already been noted. Such effects can be seen along the whole history of civilian aviation, through the various wars, into the jet age and even recently with the wide body jets such as the Boeing 747 (coming from the Air Force C5A built by Lockheed). The developments generated in this way have tended to push technology in the directions of greater speed, range and capacity. Thus, over the last forty years civilian aircraft have increased their cruise speed by a factor of three; their range by a factor of ten; and their capacities (pay load) by factors of twenty to forty. In general, though not always, there have also been comparable improvements in economy; and measured on a cost per seat mile, there has been a one-third reduction over the same period.

However, as we pointed out and as we will demonstrate later, the objectives of R/D&I programs in the military and civilian spheres are not alike, given the varying patterns of needs. With much of the new aviation technology having flowed from the military, it was only to be expected that rate and direction of such innovation did not necessarily match the changing pattern of needs of the airlines or the ultimate consumers (passengers and shippers of freight). As a consequence, new technological opportunities were being opened up in ways and at a rate that were not necessarily to the advantage of the airlines to implement and exploit, but which they found themselves being forced to adopt because of the defensive non-price competition we noted earlier. These conditions lead us to look to the producer as the source and stimulator of the technological innovation process vis a vis the airline users.

There are, however, other causes that point in the same direction and which might be expected to continue even in the absence of the external military source of technology. An airplane is a highly complex multi-component system, with many of these components operating close to their technological limits and using state of the art knowledge. As advances emerge in materials, structures, configurations, electronics, and engine design, new technical possibilities appear. These developments may have derived from many sources, inside and outside of the aerospace R/D&I systems. The research and design fields are so specialized that one time we may see advances in fuselage design; at another in flaps or wings; at another in controls and so on. A new aircraft system may, as we noted, emerge through an accumulation of many improvements in many components -- sometimes adding up to a substantial upgrading in performance. Again, such improvements may or may not coincide with user demands -- but the technological imperative and stringency of the technological demands nonetheless require aircraft and component manufacturers to be pursuing ever-continuous programs of research and development.

D. Signs of Increasing Civilian Aviation Autonomy

The drive of externally (military) fueled innovation may have culminated in the 1970 SST program. We will discuss the goals of aviation R/D&I programs later, but for now we may recognize that an SST meets virtually none of the objectives that seem to reflect the needs of airlines for new generations of equipment. It represents only an improvement in speed (made possible by the generations of supersonic military aircraft now in service). It is retrogressive on capacity, fuel consumption, range, cost of operation and environmental aspects. This does not imply that SSTs will not find a place in the market. Rather, the debate may indicate a maturation watershed for the industry. We earlier indicated 1970 as the achievement of full maturity. It may be that it marks the point at which the civilian aviation industry began to pull away from the military source of technological innovation -- perhaps even leading to a more complete separation of the military and civilian sectors. The implications could be to make the patterns of innovation so well discussed by Schiffel (29) less relevant for the future trends.

Related technological developments may be going on in the less glamorous areas of aviation innovation. In response to the growing potentials in developing countries (in the freight business, etc.), there is a growing interest in supplying low cost, short take-off and landing equipment. A combination of closer fitting of products to user needs, a substantial after-market (used planes), a growing concern by airlines in influencing the emergent features of the equipment they purchase, and the previously mentioned increasingly close coupling of NASA aircraft research with the civilian aviation industry, may all be signs of the growing autonomy of the civilian aircraft industry.

E. Summary

The nature of the aviation industry makes it vital that we recognize the extent to which the industry lives on its technological innovation base and the degree to which its policies and strategies are technologically determined.

II. HISTORICAL DEVELOPMENT

1. Development of the Sector and the R/D&I System: Institutionalization

The R/D&I process in civilian aviation could be described as highly institutionalized. More than seventy years have gone by since the first successful flight in 1903. Since then a highly developed and specialized industrial sector has grown up with a well defined division of activities both as to research and development and production roles. Substantial and specialized companies (e.g.: Boeing, McDonnell Douglas) are to be found in the areas of airframe (aircraft) manufacturing as well as in engines (e.g.: General Electric) and in other equipment (including segments of the electronics industry). In addition, the National Aeronautics and Space Administration (NASA) -- which was established in 1958 to replace the National Advisory Committee for Aeronautics (NACA), founded in 1915 -- has well defined responsibilities in the more basic R&D areas. The Department of Transportation (DOT) and the Federal Aviation Agency (FAA) have clearly deliniated roles in the implementation evaluation and control of aviation systems.

A. The History of Industrial Development

In a history of the U.S. Aircraft Industry, Simonson (31) described the period of 1903 - 1930 as that of the early industrial development. Stekler (33) described the 1903 to 1914 period as being that of initial development. Up through the end of 1913 only about 100 airplanes had been built. Stekler refers to 1914 to 1939 as the World War I and interwar period. During this period production rose to a rate of 14,000 planes per year in 1918;

Several sources were especially helpful in supplementing the experience of the authors with this sector. They are: AIAA,(4) CAB,(11) DOT,(13) Schiffel,(29) Simonson (31) and Stekler.(33) The comments of Drs. Alden S. Bean of NSF and Frank A. Spencer of Northwestern University who reviewed this section were extremely helpful.

dropping off after the war and in the depression era; and then growing steadily until 1939, during which year not quite 6,000 planes were built -- almost 4,000 of which were for civilian use.(2) World War II saw production rise to close to 100,000 per year, then settling down to around 10,000 per year (including the Korean War period).

The first specialized air transport manufacturing began in 1926 with the Ford Tri-motor(13) and by the mid 1950's the airline industry as the major civilian customer was well established. Since then until today, the industry can be viewed as having achieved the status of a mature sector with a steady pattern of growth and development. The superimposed cycles of (military) activity and the growth and partial decline of the NASA space program since the late 1950's have tended to produce something of a more volatile characteristic than for other mature industrial sectors.

We might characterize the period up through 1913 as the pre-birth phase; 1914-1939 as the introductory phase; 1940 through the early 1950's as the transition phase and the late 1950's up through 1970* as the climb to maturity; with the last few years as the beginning of the matured phase of the industry, using the Rubenstein, Radnor, Baker and McColly schema.(28)

B. Development of the Aeronautics R/D&I System

Paralleling this development of the industry has been that of the aeronautics R/D&I system. The lag in establishing an R&D base for the aeronautics sector was relatively short - as can be seen by the early establishment of the NACA (1915), the forerunner of the present day NASA organization.*

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*The date of the rejection in Congress of the SST program and the beginning of growing airline concern with costs and idle capacity.

Throughout its relatively short history the technologies of airframe design and materials, engine design, and materials and electronics have been subject to very great rates of change. These were described in a recent workshop on the Role of Technology in Commercial Aircraft Policy Formation (4) as a "very perishable property", with even relatively advanced models of aircraft being phased out in seven or eight years (p. 30). A Department of Transportation report (13) (p.8) described nine stages of aircraft development from 1926 (with the Ford Tri-Motor) through 1971 (with the DC-10/L-1011), with each being preceded by a period of R&D (largely funded by the U.S. government). Stekler (33) (p.96) took note of the increasing role of R&D as compared to production as the industry developed. This degree of dependence on R&D and the close coupling with the maturation of the industry permits us to recognize that the R/D&I system has come through the same stages of development as the sector, with little lag even at the start, and reaching a point in our time when it could be viewed as totally established in the industry.

C. Changes in Experimental and Test Facility Requirements

An additional factor leading to the degree of institutionalization of the aviation R/D&I system has come from the changing character of the experimental and test facilities required. In our era, such work can only go on when there is access to very large scale facilities (wind tunnels, flight test facilities, large computers, etc.) The consequence has been to centralize such work in NASA, the Department of Defense (DOD) and the large aeronautics firms - essentially eliminating much of the diffused university based efforts in anything but the most fundamental areas (mathematical, materials and physics). This mirrors the similar institutionalizing effects on High Energy Physics due to the need for larger experimental facilities (accelerators) as found by Radnor, Zaltman et al. (27)

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*The British had set up a similar effort six years earlier (1901) at the National Physical Laboratory. The Germans pursued such research at this time at Göttingen and the Russians at Koutchino.

2. Critical Events

A. Creation of Federal Agencies

The creation of NACA in 1915 was a landmark in the development of the U.S. aeronautics R/D&I system. A great deal of the central R&D can be traced back to work at the Langley, Lewis and other research centers that were created by NACA and which became the sources or seed beds upon which the later NASA was to be built. Federal support for aeronautics (including civilian) has always been a major factor; and by the 1958 National Aeronautics and Space Act and the Federal Aviation Act (FAA)* of the same year, "Congress made provision for nonmilitary aeronautical activities,"(13) thereby supplementing the DOD aeronautics efforts in the military sphere. The National Aeronautics and Space Council was set up to coordinate related aeronautical activities.

B. Key Historical Events

Without question the onset of World Wars I and II (and to a lesser degree the Korean War) generated major impetuses in the development of aeronautics technology, R/D&I systems and the industry at large. Significant technical developments were pushed to accelerated fruition, notably, in electronics, radar, and jet propulsion in the World War II case. The cold war acted to continue the pace of technological development in the military sphere. While there are important differences in the needs of military versus civilian aircraft requirements (to be discussed later), there has at all times tended to be a significant degree of technology transfer. Another important influence derives from the consequences of the accelerated space program of the 1960's (the Apollo-man on the moon program in particular; but not exclusively). A 1970 event of some significance was the Congressional decision not to support the development of Supersonic Transport (SST) in competition with the Anglo-French Concorde and Russian Tupolev 144 SST. The recent concerns with the energy shortage, cost, and the environment (air pollution and especially for noise) -- coming on the heels of the phasedown of the enormous space effort -- have lead to something of a revival of civilian-focused aeronautics R&D as a major priority for NASA programs.

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*Incorporated in the Department of Transportation Act of 1966.

C. Current Developments in the State of the Art

Besides the SST efforts*, some of the current developments in the state of the arts concern the design of more economical and better performing aircraft (using NASA-developed super critical wing and area rule-based configuration technologies); the design of overall systems of improved cost and safety features; and short and vertical take-off and landing aircraft. Particularly important has been the role of the airlines, with their own substantial R&D capabilities in the total design and implementation of systems into which the aircraft fit as one component (although to date, the airlines lack similar R&D capabilities in the equipment design sphere).

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*Basic research is continuing at NASA.

D. Attitudes of the Public

An interesting comment on the general public's attitudes towards the products of the aeronautics R/D&I system and of the industry is the degree to which they are accepted with little or no question. New types of aircraft have been continually introduced into airline service with virtually immediate adoption by the ultimate users, indicating a faith in the quality of the R&D, testing and evaluation, and control processes.

III. INSTITUTIONAL BASE (NETWORK OF INSTITUTIONS)

1. The Structure of the Aviation R/D&I System

Very evident in the R/D&I system is the extensive specialization between institutions. Fundamental scientific research goes on in the universities to some degree and in NASA, which carries research toward the proof of concept stage. Equipment manufacturers carry the R/D&I process forward through equipment development, design, testing, and production stages. The airline users do no equipment R&D, restricting themselves to strictly defined implementation and utilization of equipment in the larger overall airline system. Even the equipment itself (the airplane) is specialized into major components -- airframe, engines, electronics (with even subdivisions within these systems) and many or most of these are subcontracted to producers who carry on their own R&D programs. The federal government supports the more basic research, private industry the applied work.*

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*It is interesting to note that one of the arguments used in Congress to stop NASA's SST work was that in proposing to go on to a prototype stage they were encroaching on the private sector role.

Specialization goes even deeper, down to the scientists and engineers involved in the R&D process. For example, there are whole departments whose personnel may spend their lives on wing stress analysis.

Additional specialization is to be seen in the roles of FAA, DOT, and CAB, each responsible for researching and implementing specific phases of the overall air-transportation system. In turn, these governmental institutions have clearly defined control and regulation roles.

2. The Intra-System Structures

While the specialization is, as we noted, very great in the aviation R/D&I system, for the most part the work goes on in a very limited variety of institutional settings. Most of what goes on in the R/D&I system can be found at NASA (and DOD); at the airframe manufacturers and their associated (in parallel) subcontractors; and in the utilization R&D area with the airlines, with supplementary activity in DOT (FAA). Universities play a relatively minor role in the process. Figure 1 is a partial model representing these institutions and their relationships.

Thus there are three prime participants in the aviation R/D&I system: the basic technology sources (NASA and DOD in parallel), the equipment producers, and the users.* Each of these contribute specialized elements to the R/D&I process. Except for the indicated parallelism

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*It should be noted that while there are other types of civilian users (e.g.: the private and corporate aircraft market) these tend not to be a major factor in the R/D&I system.

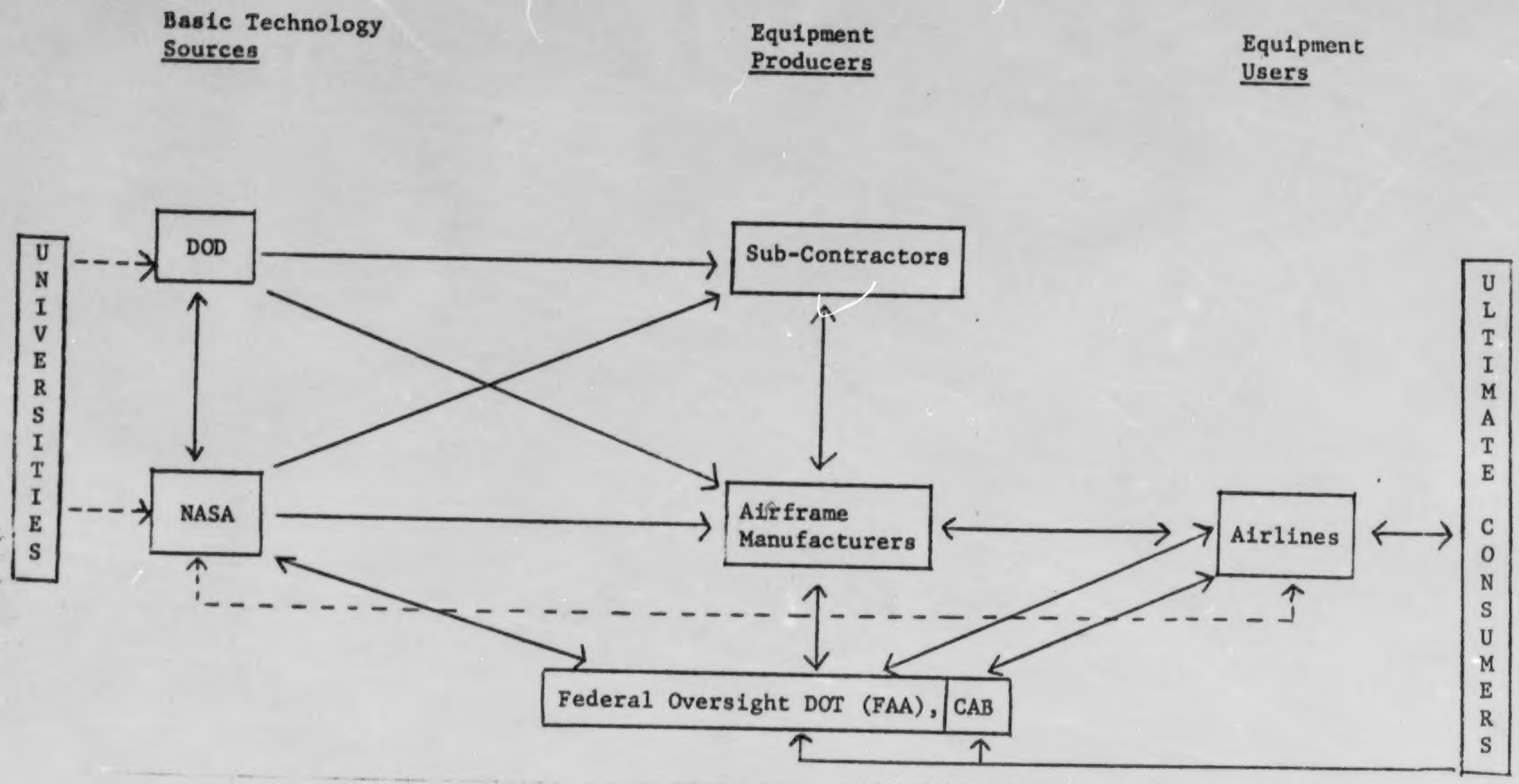
Basic Technology Sources
Equipment Producers
Equipment Users
UNIVERSITIES
DOD
NASA
Sub-Contractors
Airframe Manufacturers
Airlines
ULTIMATE CONSUMERS
Federal Oversight DOT (FAA), CAB

Figure 1

Partial Model of the Main Institutions in the Aviation R/D&I System (as between airframe manufacturers and subcontractors) the system is highly linear; there is a well established workflow; relationships tend to be most intensive between institutions with adjacent R/D&I functions; and so on. There are no obvious gaps between functions, although questions could be raised as to whether all of the most desirable linkages exist. For example, in some of our own research(6) we noted some potential shortcomings in the degree to which the airlines were connected into NASA's technological development in terms of their forward planning, and vice versa. The only areas of redundancy might be between some of the work going on in NASA/DOD and NSAS/DOT, and a federal committee was established to bring about necessary coordination.

3. R/D&I Institution Characteristics

The R/D&I system is dominated by very large institutions, whether we are referring to NASA, the major equipment manufacturers, or those airlines that play a meaningful role in the R/D&I process. While they are all highly formalized, their characteristics reflect their roles in the system.

NASA is made up of a series of research centers, each tending to specialize in some aspect of space and aviation technology. Aviation tends to represent only a smaller part of the overall NASA mission and is of concern to only a few of the centers. Some of these centers are involved in the more basic aspects of aeronautics or power plants, others in more applied flight systems programs. A center may have several thousand personnel, a large proportion of whom are scientists and engineers supported by technicians and other personnel. In their appearance and work styles these centers are university campus-like, but they are organized and managed in relatively formal ways. In the technical areas, personnel and departments are highly specialized.

Airframe manufacturers are structured like most high technology firms, but reflecting the special needs of aviation. Again there is very high specialization between departments which do R&D work, component design, systems designs, specifications, materials engineering, stress analysis, testing, etc. -- on through production, inspection, marketing, and so on. Airlines are structured around their roles of providing a service to the ultimate customers and are supported by numerous applied research, analysis and system design groups. Manufacturers and airlines stay in close touch with each other at the commercial and technical levels. Airlines become involved in the usual market research and advertising functions to stay in touch with the users of their service -- hopefully identifying needs and demand.

Finally, we might note that cooperation, licensing, and even joint ventures are quite common. In addition to the already mentioned subcontracting that goes on between the airframe manufacturers and the Producers of engines, electronics, etc., it is not uncommon to see several firms joining together to win a given government contract. The extensive specialization in the industry creates opportunities for manufacturers which can be realized through cooperation.

IV. GOALS, POLICIES, STRATEGIES

A vital initial parameter is the recognition of the size of the aeronautics R/D&I system. If we include federal funds, we are talking about an industry that spends something like six to seven billion dollars a year on combined space and aviation R&D (although only about 10% will be company funded). To this must be added the funds spent within NASA, DOD, etc., themselves. Even though the proportion of these vast amounts that are devoted to civilian aeronautics is the smaller part, it is still a very large amount, and it is embedded in and an integral part of the largest (by far) industrial R&D system.

1. Interaction Between Civilian and Military Aeronautics

As we noted, there has been a close historical interaction between military and civilian aeronautics. However, there are substantial differences in the goals of the R/D&I programs. In military R&D the programs are oriented towards the development of complete weapons systems emphasizing various aspects of performance (speed, maneuverability, hovering capabilities, as well as range and carrying load). For civilian applications (34) the objectives must be pointed towards improvements in economy (usually fuel consumption), maintenance costs (pay load), noise and polluction as well as faster cruise speed and greater range and capacity.* Nevertheless, there does tend to be a great deal of commonality in aeronautical requirements and technical disciplines(13) (p. 22). The tendency has been for the civilian sector to benefit thereby reducing the technical risk associated with the commercial application. In this sense, the military has been the field test proving ground for a great deal of advanced aeronautical technology going into civil aviation, although we have questioned this as a trend for the future.

2. Participants in the Civilian Aviation R/D&I System

Turning to the specific participants in the civilian aviation R/D&I system, the following can be observed (13) (p. 47):

> "NASA addresses the development of a research and technology program to support and enhance the various disciplines which encompass civil aeronautics. NASA also undertakes technology programs directed toward the solution of specific aircraft problem areas. Guidance is provided by the Federal Aviation Administration of the Department of Transportation (DOT/FAA) in terms of the perception of the need for technology application to both categories of interest. The government also derives assistance in developing guidance from joint government industry councils.
>
> DOT/FAA pursues airway and air traffic control technology, as well as airport and runway engineering and development, particularly as it applies to airport layout, traffic flow, vehicle movements and pavement design."

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*The differences may be continuing to increase as military aircraft take on missile capabilities and characteristics.

In addition, we could add the role of the universities which serve as a source of fundamental knowledge to NASA and DOT and which also perform certain contracted research from these agencies. Then there are the industrial firms (airframe, engine and other component manufacturers) who do the applied development and engineering design work (airframe manufacturers do very little basic aeronautics research) through the prototype to production model stages. The objectives of these latter participants have already been stated in general technological and economics terms.

3. R&D Within Civilian Aviation

Airlines have done virtually no R&D on flight equipment. Their concerns have centered on the utilization of equipment as part of the total air transportation system. Thus, airline directed R/D&I has been focused(25) on aircraft maintenance, equipment scheduling, traffic flows, passenger handling, freight and baggage handling, ticket reservations, food and beverage service and in-flight passenger entertainment; i.e.: with implementation/utilization characteristics. Since the 1970's however, airlines have become increasingly concerned with aircraft and fuel costs, idle capacity, safety, environmental issues, etc. This concern has had the effect of increasing their perception of a role in the rate and direction of aircraft innovation (essentially along the lines of more planned, controlled and need oriented equipment programs). As a result, we have seen in the last few years something of a shift in R/D&I goals. As we noted, up through the early 1970's the emphasis was on the development of aircraft that could fly faster, higher and further, and with larger pay loads at comparable costs. It was these criteria that spawned the SST. Recent emphases have been towards economy (especially in fuel), utilization characteristics, environmental impact (with noise reduction being a major priority) and life cycle costs.

4. General

Looking across the spectrum of aviation R/D&I programs and objectives we can note that as we move from the universities through NASA to the producers and then users of aircraft, the time horizons tend to shorten, the objectives and applications become more specific. It is also important to have a sense of the balance between the research, development, design, prototype building, flight test, production designs and tooling stages. Expensive as the research may be at the NASA and even company levels it is small compared with the cost of the later development and engineering through tooling phases. The investments in these later stages can be enormous. Nevertheless, as Stekler (33) pointed out, the balance between R&D and production investments has been characterized by a continuous increase in role of R&D. Whether this has begun to plateau out remains to be seen.

V. ADMINISTRATIVE PROCESSES

While the aircraft industry is managed in a generally similar manner to most large scale industrial firms, there are a number of characteristics that are particular to this context. These characteristics relate to the need to manage a process that is so fundamentally R/D&I based; the structure of the industry (particularly the fact of the critical prime/subcontractor relationships); the enormous complexity of the equipment systems; the highly codified and specified information and data base; the extent of external regulation and control; and the previously discussed economic and financial structure of the industry.

These conditions have given rise to a large number of management methods that have come to be known as aerospace management methods. These have to do with the management and control of large scale R&D projects, systems engineering and management, simulation techniques, forecasting methods, cost/benefit studies, reliability studies, contracting techniques, logistics methods, etc. The success of these methods in their application to this industry has lead some to suggest that they might be more widely disseminated, without always recognizing that their applicability may be limited by the specialized context of their source.

To attempt a complete review of the aerospace administrative Process function would require an analysis far too extensive for this illustrative analysis. Instead, we will simply list here 25 specific techniques and concepts derived from the aerospace industry as discussed by Milliken and Morrison.(21) It is to be borne in mind that their paper was written for the general business community (in the Harvard Business Review) with a view to promoting the possible diffusion of these techniques and concepts.

1. Systems Analysis
2. Cost/Effectiveness
3. Decision Analysis
4. Heuristics
5. Simulation Modeling
6. Forecasting
7. Delphi
8. Systems Engineering
9. Reliability Analysis
10. Maintainability Analysis
11. Value Engineering
12. Project Management
13. Matrix Structure
14. Government/Private Corporations
15. Procurement Systems
16. SEB Process
17. Incentive Contracting
18. Contractor Performance Evaluation
19. Management Information Systems
20. Reporting Display Systems
21. Scheduling/Status Recording
22. PERT/CPM
23. Configuration Management
24. Logistics Management
25. Quality Assurance

VI. PERSONNEL BASE

The aircraft industry uses very large numbers of scientists and engineers as well as other highly skilled management and control personnel. In 1971 out of a total employment of over one million, 175,000 were scientists and engineers (it had been 56,000 higher in 1967) and 58,000 technicians.(13) These tend to be highly specialized personnel, and having the proper mix and quantity of personnel in specific areas is critical. Use of skills inventories is one method of keeping on top of this issue.

The industry is notorious for its ups and downs (mostly reflecting the shifts in military and space programs) resulting in massive hirings and layoffs of highly skilled personnel. This can be misleading to the outside observer. Thus a great deal of skilled technical work in developing an aircraft consists of highly programmed detailing (e.g., stress analysis). In many ways this is R&D production work. When large numbers of engineers are laid off the brunt of the cutting is in these direct R&D production areas. Protected are the core R/D&I personnel without whom it would be impossible to develop future programs. Even for the core group there must be turnover. The high rate of obsolescence of skills demands a continual infusion of new blood.

Salary levels tend to be high and there appears to be some status associated with working in the industry. Naturally there is great mobility within the industry, as various firms wax and wane with the success of their programs.

VII. FUNDING

The importance of U.S. government funding has already been mentioned (the government was largely responsible for supporting the R&D that preceded most of the major technological advances). Over the ten year period of 1958-68, the federal government spent about $5 billion per year on industrial R&D in aerospace, while companies were spending between $1/2 to $1 billion per year of their own funds. Fitzsimmons of McDonnel Douglas(4) estimated that in 1974 total U.S. aeronautics R&D was "down to a total of something like 10 percent of civil sales." This would generate something like $6 to $8 billion in civil aeronautics R&D by 1985. Together this represents an enormous R&D base (even though most of the direct expenses may have been non-civilian oriented.)

Funds from the U.S. government that can benefit civilian applications are those going to NASA for specific research programs, and the independent R&D allowed on defense contracts. Company funds must be generated by sales.* This has tended to produce instability for firms.

The life cycle of a development program through production up to first sales can be very long. Firms must risk very large investments in R&D, tooling and first production before much revenue comes in to repay the investment. The elapsed time could easily exceed ten years.

Average rates of return tend to be somewhat below the rest of industry. Combined with the high risks, the sector has not proved attractive enough to keep all the firms in or attract new entries, resulting in the oligopoly situation to be found today. Without governmental support of one sort or another, the predominant role of U.S. manufacturers and the flow of innovation would not have been possible.

VIII. INFORMATION FLOW

At the basic research level (but excluding work from the military sphere) the flow of information within the industry and between industry and government tends to be relatively free. There is wide exchange of ideas, even on an international level, with publication, laboratory visits, etc., being common and hence essentially uncontrollable. In the more applied development and design phases, in the application to production, companies attempt to control information flow and to maintain secrecy.

IX. INNOVATIONS

The innovations in the aviation sector have very large-scale requirements.

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*Direct to airlines or to institutions who then lease to airlines.

Costs are enormous, especially for development, but there is a large amount of federal funding of basic and applied research, and (through DOD contracts) of development. As the innovations themselves are very close to the state of the art, there is a high level of complexity and sophistication of technologies involved. Many highly skilled, specialized personnel are required. Long time spans are involved. Thus, very complex R/D&I systems are required. We find coordination and orchestration of the system being done by NASA at the research stage and by airframe manufacturers at the development through implementation stages - - and cooperative relations throughout the innovation process with support service organizations.

From the user side of the R/D&I process, the innovation requirements involve performance/cost improvements and the need for the innovations to "fit" into the user's operating system and capabilities.

Additional requirements exist in terms of the multitude of governmental regulatory and control activities in relation to performance, safety, etc.

The real life cycle of civilian aviation innovations is quite long - - indeed the older propeller planes have had very long real life cycles. Safety and air worthiness are the basic criteria for the limits of real life, requiring a continual process of maintenance and updating of equipment. While the real life is long, the competitive life in the initial, primary market is much shorter - - with aircraft being sold to an "after market" (small airlines; cargo) before the real life cycle is completed.

The quality of the innovation is a critical element of the R/D&I process - - both in terms of the objectives of cost/performance improvements and in terms of safety and reliability factors (as already noted). Thus, the innovations must be (and actually are) highly testable.

For the most part, the innovations are limited to aviation per se, but there is a fair degree of "spin off". Aircraft themselves can be adapted to a variety of applications (passenger/cargo; long or short haul; military/commercial).

From the perspective of transportation objectives, innovations in the civilian aviation sector have been of great benefit to society. However, we have already noted that many people are beginning to question the larger costs of noise and environmental pollution; and that innovations have at times been "forced" onto the airline companies.

X. NEED IDENTIFICATION

The degree to which airline needs for flight equipment are determined by a complex interaction of competitive and technological forces has already been discussed. From this we saw that it is difficult to separate airframe manufacturer responsiveness to airline needs from their behavior in generating these needs. Thus the locus of need identification can be visualized as the intersection of ultimate consumer demand as transmitted through airline planning and the output of the aircraft production R/D&I system.

Airlines depend on market research, demand analysis and sophisticated planning functions to identify and translate ultimate consumer demand into equipment requirements, in the light of techno/economic/political conditions. These are converted into equipment operating, economic and environmental requirements. Equipment producers stay in close touch with the airlines own need identification efforts but attempt to achieve a leadership position by translating technological opportunity into features that meet current, potential or stimulatable user needs. Since producers must ultimately compete for the airline equipment business (despite the oligopoly structure of the industry), something of a balance between the airlines and the equipment producers is achieved. That this balance is not always totally achieved is demonstrated by the recent airline experience in over-acquisition of wide body (jumbo) jets, which generated considerable over and idle capacity; and by some of the apparently less than ethical tactics of manufacturers in their marketing efforts, which have been coming to light in recent days. In general, however, the process that can be observed over many years has been one of relatively smooth integration of emerging technology into new equipment that meets the changing patterns of consumer demand.

XI. GENERATION/RESEARCH

We can usefully introduce this section by quoting directly from the American Institute of Aeronautics and Astronautics (4) statement on the Design of Aircraft (p. 30):

> "Design technology, as it relates to the field of commercial aircraft, is largely conceptual in nature. It constitutes the basis for the selection of not only the final product itself, but also the individual components or supporting elements of that product. In another sense, it includes the methodology used in realizing the basic design concept, as well as the logical integration of the many individual elements -- components, subsystems, and procedures -- into the complete, functional aircraft system.
>
> It is possible, of course, to identify and to discuss the specific technological elements of the design process; e.g., computer-aided structural, aeroelastic, and aerodynamic design methods, supercritical aerodynamics, "winglet" vortex dissipators, graphite-epoxy composite structural elements, numerically-controlled manufacturing processes, etc.."

The above statement well illustrates the extent to which the development and design phases of the R/D&I process depend on detailed and scientifically based bodies of fundamental knowledge in physics, fluid dynamics, structures, materials, etc., as well as in combustion, heat transfer, electronics, and so on, for the non-airframe components.

This knowledge comes from basic research going on at the universities, but more substantially at NASA and DOD and to some degree in industry, with this last sector taking on the major applied research role. Both laboratory and field research are involved. materials testing laboratories, enormous wind tunnels, simulators and large scale computers combine with extensive flight testing of new concepts to provide the experimental base for the aeronautics parts of the field, with similar situations existing for the R&D on engines and electronics, etc.. This phase of research generally stops short of prototype development.

The nature of the R&D is such that it is often carried out by teams rather than individual researchers, with many project teams reaching very large size. While creativity is important (as always), progress more typically occurs through the accumulation of a myriad of detail advances in the state of the art. Really revolutionary new concepts have been relatively few. In the civilian sphere (as opposed to the military) publication of results at the basic research level is fast and open. Interstage technology transfer is achieved rapidly and efficiently. Even though, as we noted, much of the research goes on in large mission oriented institutions (NASA, DOD, big companies), a very professional environment is maintained within well planned and controlled programs. NASA research centers, for example, provide research environments equal to or better than those at most universities.

R&D programs may be focused around specific applications (such as an SST or a vertical take off and landing [VTOL] aircraft, etc.), or around problem areas (materials, noise, energy, pollution, speed, etc.). In fact, something of a matrix exists between problem and product-directed programs, with a fair degree of interchangability. Thus, Congressional action could stop NASA's SST program but might still leave intact most of the applied research that was required for the SST objective. Thus it is possible today for NASA to be fairly advanced in SST research without having had such a program.*

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*The maintenance of national technical readiness even without a hardware program is seen as one of NASA's missions.

XII. DEVELOPMENT

The really complex and high cost aspect of the R/D&I process is that which goes on within the industrial firms in the transition from prototype to production ready and tested designs. The design phase is critical for the success or failure of the firms in the industry. As we implied earlier and as Harlan(16) (p. 10) has noted, design is the arena of airframe manufacturer competition, leading potentially to major gains or losses of market share (i.e.: a much more sensitive situation than that which might be found, for example, even in the style conscious automobile industry).

Development of the prototype is a critical stage. Where this occurs is not always clear-cut. NASA typically modifies and experiments with aircraft as part of their research effort. At what point a new concept has emerged in prototype form is not always obvious, although formally the building of production prototypes is the role of the manufacturers -- and for specific models this is clear-cut.

Development through engineering and design processes is highly sophisticated and specialized. Numerous departments deal with component design, systems integration, performance analysis and testing, etc. The ultimate tests take place in flight testing.

Technology transfer is a critical element of the development function of the aviation R/D&I system. We have already mentioned the military-to-civilian aspect. For example, the development and purchase of a C5A transport by DOD from a given firm makes development of a civilian passenger aircraft of this same (wide body) type much more feasible.* Similarly, development of a new generation of equipment by one company will be quickly followed by its competitors. Far more difficult are attempts to transfer technology across national boundaries, as for example, when companies in one country assemble aircraft (using some local components and materials) designed elsewhere (such as Fokker of Holland assembling Lockheed airplanes). Always difficult, this may be compounded by the very complexity of the aircraft system, with its highly critical interdependence of materials, design and function, and possibly reflecting cultural as well as economic and resource differences. Thus, for example, materials engineering became a major and near determining function in the effort of Israel Aircraft Industries to produce initially French-designed and then self-designed equipment.

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*Recent legislation forbidding prototype building on DOD contracts without a clear military mission may be limiting such inter-program technology transfer.

XIII. PRODUCTION

1. A Custom Shop Process

The production process for aircraft is more reflective of a custom shop working on batch orders than that which laymen visualize as the typical high production industrial scene. While there are production shops that use presses, cutting and turning equipment, etc., to produce components, the main manufacturing areas are large hangar-like spaces in which a batch of aircraft are painstakingly built up, giving manufacturers a fair degree of flexibility in introducing new designs into the production process. The cost of tooling remains a major component of the total investment, since to an important degree each new aircraft system requires the design and fabrication of new manufacturing, assembly and test tooling -- much of it of a very costly nature. Nevertheless, as was noted by DOT(13) (p. 58) 75% of costs are in personnel (development as well as production) -- i.e.: it is a labor intensive industry.

2. Control Systems

The production control system is geared around the custom shop environment. Relatively little production is for stock, and most major airline customers require variations in features. Thus, production plans have to be geared to specific orders and customer determined delivery schedules. Since lead times for obtaining and manufacturing components and for the actual assembly are long, careful and detailed planning is required.

3. Structure of the Aircraft Manufacturing System

It is important to clarify the structure of the aircraft manufacturing system. As Harlan (16) noted, airframe manufacturers "do not manufacture, in the strict sense of the word, all the basic components of the planes they produce." Rather, the airframe manufacturers act as the "prime" producers of the equipment and they purchase engines, electronics, etc., from other industries who act as "subcontractors." Stekler (33) speaks of "prime contractors, associate prime contractors, subcontractors which manufacture systems, and subsystem manufacturers." In any case, the selection and control (cost, schedule and quality) of subcontractors becomes a major production issue for the prime airframe manufacturers (12,16).

4. Quality Control

Quality control and inspection (both in-process and final) are of central importance in the production process. Unlike most other products, aircraft manufacturers cannot afford to correct their mistakes in the field. Despite (or perhaps as indicated by) complaints to the contrary (compared to almost all other sectors), this industry can be seen as paying great attention to product quality and safety. Anything else would be disastrous in both social and economic terms. There is no place for seconds. This issue becomes compounded as a source of problems, given the great rate of obsolescence of aircraft and the consequent inability to upgrade quality and design over time as part of the usual learning curve. Another compounding problem is the degree to which materials and structures are extended to the feasible extremes of their capabilities in consort with the need to keep weight down to a minimum.

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

This feature includes several aspects of the "bridging" function between knowledge producers and knowledge users. In the civilian aviation sector, the primary issue is marketing, and we will thus limit our discussion to marketing.

1. Market Growth

An important parameter for marketing is the fact that the airline market (as measured, for example, in revenue passenger miles) has had a substantial and steady growth. Some (e.g.: Steiner(32)) have projected that this will continue to grow at 6-8% per year over the next decade, so approaching 1,000 billion revenue passenger miles by 1985 (excluding the Communist world markets) -- which translates into a $60-80 billion aircraft sales market.

2. Individual Firms: Feast to Famine

While the gross volumes sound, and are, impressive, they must be evaluated in the light of their fluctuating character, particularly for any given firm. Given the changing character of equipment with the fact that demand may shift by substantial degrees following technological advances, firms may well swing from feast to famine. Actually, the military (rather than the civilian) markets have been the worst or most fickle customer as far as creating conditions of volume fluctuation for the manufacturers.

3. Product Positioning

The positioning of products as to capabilities, features and price is critical. Different aircraft can serve different markets more or less efficiently (or at all). Thus the type of equipment needed for trans-oceanic flight differs from those required for short haul internal travel. Also,(4) it has been stated that there is a growing need for thirty to fifty passenger aircraft designed for operation in short haul city center to city center markets (in response to a demand for such service in the U.S. and even more abroad), thus indicating a market segment that may be growing at a faster rate than others. New equipment must be designed to fit such changing market segmentation.

4. Predicting/Stimulating Future Demand

This indicates the importance of knowing and being able to predict and/or stimulate future equipment demands from airlines at home and abroad. It then becomes the task of top level sales personnel to obtain orders for sufficient volume to permit the manufacturers to make the necessary investments into tooling and manufacturing a new product, thereby establishing a market (usually with one or more major airlines) that others will follow. As noted above, production, will, by and large, then be tied to the specific additional orders that can be generated. The previously discussed need for airlines to compete in non-price areas (through product and service differentiation), together with the matching of aircraft performance to service needs, becomes the focus of equipment sales efforts. Thus, close customer contact on a personal basis is obviously a requirement for successful sales efforts. The airlines attempt to capitalize on having innovations in equipment, usually by assigning them first to the most competitive routes (where possible) and by maximizing their publicity to promote their use of new equipment (e.g.: as Pan American did with the Boeing 707's and 747's and American Airlines with the DC10's).

5. Obsolescent Equipment: The After-Market

It is of interest to consider what happens to the equipment that becomes obsolete in this process of rapid innovation and proactive marketing. There is a substantial after (used) market for aircraft in secondary airlines and cargo transportation. The ability of major airlines to sell obsolete equipment has helped them to finance the investment in new aircraft, thus helping fuel the innovation process. However, growing demands for such products may be offset by reductions in equipment life (of the big jets) and increased cost and complexity of maintenance. The future of the aircraft after-market and its impact on the R/D&I process has still to be determined.

6. Marketplace Characteristics

The economic and political characteristics of the marketplace are important. As noted, there are only a very few major airframe manufacturers. The number of airlines is greater, but in many of these cases (e.g.: for the national airlines of other countries), political and national economic considerations compete with airline economic factors in determining what is bought, when, and from whom. Additionally, an airplane must meet any local legal and regulatory requirements (e.g.: see the debate on permitting the Concorde landing rights in the U.S.) that may be slanted to serve national interests. Also, manufacturers may be supported to greater or lesser degrees by their governments for larger economic, security or prestige reasons (e.g.: Lockheed in the U.S. and Rolls Royce engines in the U.K., to name but two highly publicized examples.)

Finally, it is important to recognize that the major airlines (the smaller ones tend to follow their lead) are relatively sophisticated customers. They are well informed on the operating and technological characteristics of the products they buy, and highly skilled in their implementation and utilisation. That is not to say that they do not make mistakes (as for example with the DC7's and Boeing 720's which turned out to be inferior to their predecessors, and the failure of the turbo-compound engines).

7. The Producer's Task

The producer's task is to create a set of conditions (technologically, competitively, price, delivery, and terms-wise) that make the purchase of his product the most rational decision for the airline to make (subject to the political, legal and economic considerations: e.g.: currency availability, constraints that may be operating at the time).

XV. ACQUISITION

Airplanes are very expensive products, and, as we noted, represent the major part of an airline's investment. Airplanes are also a major determinant of their competitive capacity. That is to say, airlines cannot afford to fly inferior aircraft. Thus, deciding what to buy and when can be the most critical decision an airline can make. Airlines therefore make it their business to stay aware of new developments from their very earliest stages, even ordering before the first production airplane has been completed, in the hope of gaining a competitive position. They are equally prone to cancel orders if problems (performance, delivery, political or economic) appear -- creating a very unreliable market. A major continuing constraint is the ability to finance the rapid and expensive new product introductions that may make obsolete their present fleets.

Schiffel (29) lists the following factors which he says should be taken into account in making the acquisition decision:

1) Overall demand for air transportation and the demand in relevant specific markets;
2) Extent and character of price flexibility and competition;
3) Price (or rate or fare) level and structure;
4) Extent and character of non-price competition, including that embodied in flight equipment, enroute and ground services, etc.;
5) Extent and nature of market competition;
6) State of aviation technology;
7) Availability of investment capital;
8) Availability of "suitable" aircraft;
9) Capital cost of flight equipment;
10) Operating cost of flight equipment;
11) Exposure to risk; and,
12) Aircraft manufacturers' sales policies.

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Equipment may be purchased because it is seen by an airline to have an optimal fit with its present route structure. However these structures can and do change and the impact on the "fit" may be hard to predict, sometimes leaving the airline with less that optimal aircraft for their routes.

Another important concept is that of the "launching purchaser"; i.e., an airline that launches a new airplane by becoming its first acquirer and promoter (as did American Airlines with the DC 10 and Pan American with the Boeing 747). This gives the airline the initial competitive edge while absorbing the risk of introducing an innovation, and may lead to other airline adoptions, the objective of the manufacturer. Some foreign countries may give governmental support to their airlines to pursue such a policy (e.g.: in France).

Acquisition decisions are critical for the airlines. As we pointed out they are sophisticated buyers, even though mistakes have been made. With the ever-increasing cost for equipment and the growing financial constraints, the selection behavior has become even more analytical, displacing some of the "old boy" network considerations that may have tended to exist in the past. This need for careful analytical planning has become reinforced as airlines, particularly more recently, have come to recognize the system-wide implications of the aircraft acquisition decision.

XVI. IMPLEMENTATION AND UTILIZATION

1. Implementation

A. Close Producer/User Coordination

Implementation in the aviation industry often begins while the design is still on the drawing board. There is close coordination between producers and users to tailor the equipment to the needs of the airline. Even after the model is in general production, the specific order will be tailored to user desires. How the airline will use the aircraft and the criteria that will be used to evaluate performance are well defined in advance of implementation.

B. Implementation Requirements

The requirements to actually implement a new aircraft are many, With operating features such as speed, range and capacity likely to be changed by a new acquisition, revisions may be needed in operations, routes, schedules, etc. Maintenance requirements and facilities are likely to be different and will require preparation. This can be a costly and long process, demanding considerable pre-planning. Retraining requirements for crews and maintenance personnel can be very extensive. The general public may need to be prepared with major promotion programs. Trial runs will normally precede general introduction into scheduled flights. Thus, a decision to introduce new equipment usually implies a major change on a system wide basis. While the airlines are highly skilled in carrying out such changes, new acquisitions do generate major disruptions for airlines.

C. Software Aspects

So far our discussion has focused on the hardware aspects of the aircraft. At this point it is also important to note that there are software dimensions to the product that play a vital role in its implementation and utilization. The manuals, specifications books, parts lists, etc., that come with an airplane are unbelievably extensive. Complete specifications of operation, maintenance, parts and so on are a vital component of an aircraft system. Without them, implementation would not be possible.

2. Utilization

A. System Impact

New equipment can be used to supplement existing aircraft in a growing market, or may be used to open up new routes where this is permitted and desirable. When it supplants existing aircraft, these may be moved to other routes or applications or sold in the after-market. When the change is a radical one (as was the first introduction of jets in the late 1950's) then a whole restructuring of the system is required to accomodate the new approach. Personnel and facilities need to be reoriented and changed.

B. Barriers

The incentives to innovate have already been discussed. The barriers are generally cost, customer acceptance and political, legal and regulatory constraints. There are also potential system level technological constraints and barriers. For example, not all airports had runways that were long or strong enough to take the first generations of jet transports. There may be similar deficiencies in air traffic control capabilities. Thus it is not enough to have a better airplane. The airplane must be capable of being congruent to the systems of which it becomes a part, or conditions must be extant that permit other system features to be upgraded (build better runways, etc.). Finally, we are today also recognizing the extent to which aircraft have an important impact on our environment and that this impact must be considered as a utilization criterion.

C. Servicing and Maintenance

Once in service, aircraft must be serviced and maintained (including parts and components replacement) in a frequent, detailed and prescribed manner. Also, from time to time, changes will be incorporated requiring testing and approvals. Unlike most other equipment, aircraft have to be kept at a near-new condition at all times. Preventive maintenance and replacement is the norm. Failures of even minor components relating to the operation of the airplane can cause grounding. Costly spares have to be inventoried in various locations. This all adds up to a costly and critical aspect of equipment utilization.

XVII. SUPPORT SERVICES

Since the aircraft industry is in fact an amalgam of several industries (airframe, engines, aircraft electronics, etc.) it is not really feasible to discuss support systems as a separate feature. Many industries provide components to either the primes or subcontractors, and the cost of building an airplane would be prohibitive but for the existence of this structure of suppliers. Much the same could be said for the equipment (production and testing) suppliers, and for the many organizations providing services to airlines. Large airlines will have their own service functions in many areas. Small lines can contract these out. Various types of companies have emerged specializing in the provision of various kinds of services. Thus, Stekler (33) notes that there have even developed management companies providing systems management and coordination services (e.g.: TRW, Aerospace Corp.) to DOD and NASA.

XVIII. EVALUATION RESEARCH

As we noted, aircraft are subject to extensive component and system testing and evaluation through development and during and after production, with this meticulous process continuing into service (for equipment used to provide service to the public). No airplane can be introduced into commercial service which has not received FAA certification. Once in service detailed records have to be kept on flight history, maintenance records, changes, etc. Unusual experiences or crashes can lead to the grounding of all aircraft of a given type. When an anomaly or crash does occur, detailed investigations are made to identify the causes and to institute corrective actions as seen necessary. The airlines make their own cost, reliability and customer response evaluations of new equipment.

As we noted, the civilian area depended in the past on the military for considerable technology transfer which included reliability, safety and proof of concept data. The airlines would not generally buy an airplane that had not been flight tested by the military. With the divergence in needs and the changes in the law regarding DOD contracts, this may become far less feasible and hence represent a major added cost factor.

XIX. RESEARCH ON R/D&I

We are not aware of any previous attempt to analyze and describe the civilian aviation R/D&I system from a comprehensive contextual perspective. This is not to say that there has not been much research on various aspects of R/D&I in the civilian aviation sector. Obviously, much has been done, as the list of references at the end of this chapter will indicate. Thus, we find many studies on such aspects of civilian aviation R/D&I as the economics of the aircraft and airlines industries(10, 24, 29, 32, 33, 34); the nature of the industry(2, 7, 11, 13, 15, 20, 30, 31); the effects of technology on economy(23, 25, 26) and on the industry(4); on the technology per se(3, 5, 8, 17, 19, 22); on planning and operations(6, 12, 16, 18, 21); etc.

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See also references in the Milliken and Morrison (1973) paper included as part of this discussion.

CHAPTER FIVE

THE R/D&I CONTEXT IN THE HEALTH SECTOR

Major contributions to this chapter were made by Thomas Pipal and Robert D. Hamilton, III.

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XIX. RESEARCH ON R/D&I 417

Perhaps the two words which most accurately characterize the health R/D&I system of this country are growth and diversity. Until World War II, funding for health research came almost exclusively from private foundations; the vast majority of these funds being spent for clinical research. Government involvement at all levels was episodic and ephemeral.

By 1947, the medical R&D programs established during World War II had come of age. The development and wide use of such wartime discoveries as penicillin, gamma globulin, sulfonamides, and cortisone had shown the value of concentrated, directed approach towards medical research.

In the twenty-five years from 1947 to 1973 total expenditures for health R&D increased by a factor of 40 (from $87 million to $3.54 billion) in constant dollars; government expenditures by a factor of 82 (from $27 million to $2.23 billion) (NIH 1974). Indeed, these dollar amounts are somewhat understated because they do not include those funds spent for research on the organization and delivery of health services.

The diversity of the health R/D&I systems can be most easily seen in the multiplicity of problem areas under consideration and the number and kind of institutions involved in the process.

Applied research focuses specifically on the clinical aspects of health care. Examples of this activity include the development of a rubella vaccine, organ transplant techniques, and the continued exploration of a wide range of pharmaceutical agents (e.g. chemo-therapy for cancer, broad spectrum and specific antibiotics, drug therapy for psychiatric disorders, etc.). Also, developments in rehabilitation techniques including the use of mechanized prostheses would fall into this category.

Active research programs are to be found at most university medical schools; teaching hospitals; numerous state, local and voluntary hospitals; private research institutes; governmental research facilities; and many places in the private sector. Clinical areas under consideration include aero space and nuclear medicine, pediatrics, epidemiology, pharmacology, virology, hematology, psychiatry, obstetrics, neurology, immunology, internal medicine, surgery, pathology, radiology, and numerous others. Within these disciplines, special research efforts in specific disease categories receive special attention. Cancer, cardiovascular diseases, muscular dystrophy, multiple sclerosis, cerebral palsy, and cystic fibrosis consume large portions of the research dollar. Also, the basic life sciences, medical technology, and related studies in the physical sciences and engineering command considerable support. Obviously, this list is by no means exhaustive of the topics treated within the health R/D&I system. It should serve, however, to indicate the vast diversity in the field.

This analysis attempts to describe and define the basic nature of the health R/D&I system as it has evolved in the United States, using the nineteen contextual features of the contextual analysis framework described in Chapters One and Two. This will allow comparison with the contextual analyses of the education, aviation and criminal justice sectors provided in other chapters of this volume.

Two points must be noted here. First, this analysis is descriptive, not prescriptive.

Second, because the area of "health" can include a broad range of considerations, it is necessary here to focus on a particular aspect of health. Specifically, this analysis focuses principally on the health services aspects of health R/D&I. It does not include consideration of such areas as health education, preventive medicine, mental health, alcoholism or drug abuse.

I. ENVIRONMENT

1. Political Conditions

As will be noted later, the Federal government has become the primary funding source for the field. (Table I). At the present time over 60% of all medical R&D in this country is Federally sponsored. In addition to this, many sectors of the field are almost totally dependent upon Federal monies.

Because the Federal government supports over 60% of health related research in this country it has an enormous impact on the levels and consistency of research funding. Federal grants and contracts provide over 40% of the revenues of the nation's medical schools. Sixty-three percent of these funds are for research and development. The Federal government, however, is as dependent upon the institutions as they are upon the Federal government. Assuring reasonable stability serves the interests of both parties. The recently convened President's Biomedical Research Panel (1976) spoke against the fluctuations and recommended that the Executive Branch and the Congress authorize forward funding of extramural grant and contract supported programs.

If we eliminate the approximately 30% of R&D expenditures made by pharmaceutical and hospital equipment firms, the dominance of the field by the Federal government (and thus the dependency of the R&D system) becomes readily apparent.

2. Funding - Political Problems

Funding of research is both a scientific and political process. The budgets proposed by each administration are based on ceilings originating in its Office of Management of Budget. The Department of Health,

TABLE I

PROPORTION OF TOTAL FEDERAL RESEARCH AND DEVELOPMENT FISCAL YEARS 1947-73

Fiscal Year	Total Federal R. & D. (Including national defense and space exploration)[1]	Total Federal medical R. & D.[1]	Medical R. & D. as a percent of total Federal R. & D. (percent)
	Millions of dollars		
1947	691	27	3.9
1948	863	56	6.5
1949	1,105	84	7.6
1950	1,175	109	9.3
1951	1,812	105	5.8
1952	2,194	126	5.7
1953	3,361	121	3.6
1954	3,039	131	4.3
1955	2,745	143	5.2
1956	3,267	171	5.2
1957	4,389	267	6.1
1958	4,906	318	6.5
1959	7,123	407	5.7
1960	8,080	496	6.1
1961	9,607	628	6.5
1962	11,069	838	7.6
1963	13,663	1,002	7.3
1964	15,324	1,139	7.4
1965	15,746	1,287	8.2
1966	16,179	1,424	8.8
1967	17,149	1,530	8.9
1968	16,525	1,626	9.8
1969	16,306	1,706	10.5
1970	15,834	1,688	10.6
1971	16,161	1,900	11.8
1972	17,109	2,217	13.0
1973 est . .	17,992	2,334	13.0

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[1] Includes expenditures for research facilities.

Source: Medical and health-related research data; NIH. Total Federal R & D (1947-71) - Federal Funds for Research and Development and Other Scientific Activities, National Science Foundation Vol. XXI. 1972-73 Special Analyses, Budget of the U.S. Government, Fiscal Year 1974.

Education and Welfare allocates portions of the whole budget to the NIH and Alcohol, Drug Abuse and Mental Health Administration. The Institutes then have to modify their figures to fit their proposed budgets into the given overall figure.

The Congress, however, has the power of the purse. It appropriates the funds for health research. It is subject to the political pressures of its constituents as well as the persuasions of the various interest groups around the health R&D trough. Both groups have historically focused on curing the well-known killer diseases rather than on the preventative aspects or the economic costs associated with disease. The imbalances that this focus has wrought are shown below (Weary 1977).

Not only are there serious imbalances between the various institutes but within a particular institute there may be gross distortions of the research funds expended for a particular disease in relation to its economic costs. The National Institute of Arthritis, Metabolism and Digestive Diseases is a good example. This is a case where the political strength of certain lobbies and the appeal of a particular disease can alter a rational, scientific allocation process.

In general, funding medical R&D is a relatively "safe" proposition for legislators. National health insurance remains a controversial issue, but few question the worth of continued research. The question therefore is not so much whether or not to support research, but rather what research to support, and at what level.

3. Social Factors

There are three social factors of some significance to the health R/D&I system. First, despite the danger inherent in drawing conclusions from

TABLE II

COMPARISON OF APPROXIMATE AMOUNTS OF MONEY EXPENDED FOR RESEARCH BY CATEGORY OF DISEASE PER DOLLAR OF ECONOMIC LOSS TO SOCIETY*

CANCER	4.7	CENTS/DOLLAR	OF	ECONOMIC	LOSS	
NEUROLOGICAL-STROKE-COMMUNICATIVE-EYE	2.0	"	"	"	"	"
DIABETES-ENDOCRINE-METABOLISM-NUTRITION	1.8	"	"	"	"	"
MENTAL HEALTH	0.8	"	"	"	"	"
HEART-LUNG-BLOOD	0.7	"	"	"	"	"
KIDNEY - UROLOGY	0.4	"	"	"	"	"
ARTHRITIS-BONE	0.3	"	"	"	"	"
SKIN DISEASE	0.3	"	"	"	"	"
DIGESTIVE DISEASE	0.2	"	"	"	"	"

* NOTE: ECONOMIC LOSS FIGURES ARE 1972 WHILE RESEARCH EXPENDITURES ARE 1977 FIGURES

TABLE III

ANALYSIS OF ECONOMIC LOSSES TO THE AMERICAN PUBLIC OF CATEGORICAL DISEASES FOR WHICH RESEARCH IS PREDOMINANTLY SUPPORTED BY THE NATIONAL INSTITUTE OF ARTHRITIS, METABOLISM AND DIGESTIVE DISEASES(1)

	TOTAL DIRECT COSTS AND ECONOMIC MORTALITY & MORBIDORY LOSSES (COSTS + LOSSES)		1976-77 APPROPRIATIONS LEVELS	
	IN MILLIONS	%	IN THOUSANDS	%(2)
ARTHRITIS AND BONE DISEASES	8,948	4.7	31,135	1.2
DIGESTIVE DISEASES	11,937	6.3	29,012	1.1
DIABETES AND ENDOCRINOLOGIC, METABOLIC, NUTRITIONAL DISEASES (3)	5,930	3.1	106,662	4.1
KIDNEY AND UROLOGIC DISEASES	6,456	3.4	24,120	0.9
SKIN DISEASES	2,052	1.1	5,916	0.2

(1) NOTE: ECONOMIC COST FIGURES DERIVED FROM FEB. 1976 ARTICLE BY COOPER AND RICE IN SOCIAL SECURITY BULLETIN WHILE RESEARCH SUPPORT FIGURES ARE FROM 1976-77 LEVELS OF APPROPRIATIONS.

(2) NOTE: PERCENT IS BASED UPON COMBINED TOTAL OF N.I.H. APPROPRIATIONS (MINUS CAPITAL EXPENDITURES) + ADAMHA MENTAL HEALTH RESEARCH APPROPRIATION TOTAL $2,570,286,000

(3) DENTAL DISEASES EXCLUDED FOR COMPARABILITY WITH COOPER & RICE ARTICLE

trends it is useful to examine the growth in spending on health. In 1960 about 5% of the Gross National Product ($30 billion) went for health; by 1970, $70 billion (7% of GNP) was spent. By 1980 it is estimated that health will absorb over 9% of the GNP for a total of $200 billion. (Hepner and Hepner 1973). While there is controversy as to the impact of a national health insurance program that could lead to further increases in demand, at the very least it indicates an increasing social place for health care in our present and future lives.

On the negative side, the increased activity of consumer groups has lead governmental regulatory agencies such as the Federal Drug Administration to impose stricter guidelines on the development and production of a wide variety of goods and services. Longer and more rigidly controlled testing procedures, as well as validation of results, places a significant burden on the private sector of the system. Non-profit organizations in the field are also subjected to more stringent review of research proposals, particularly with regards to the ethics of the methodology and the applicability of anticipated results.

The third social factor impacting the system is the willingness of practitioners to incorporate new products into their present activities. Moral considerations aside, the number of malpractice suits filed annually has increased dramatically, over 90% in the last seven years. It is now estimated that one out of every four doctors presently practicing will be sued for malpractice before the end of his/her career. (Time 1974). Partly, this increase may be the result of an increased specialization evidenced by the medical community. Patients may be better informed and less tolerant of physicians' mistakes; furthermore, they may feel less qualms about suing specialists (whom they do not know personally) than about suing the general practitioner whom they do know. The malpractice trend may initially lead to more conservative adoption of new technologies or therapies. It will also place tremendous pressure on the doctor to stay current.

Despite its many problems, however, it is difficult to argue with the conclusion that health R/D&I has been successful and effective within the spheres in which it has operated. This is even evident in the developing countries which have benefited from the transfer of relatively unsophisticated health technologies (such as innoculation, use of antibiotics, sanitation, etc.) from the more developed societies. There the reductions in infant mortality and increase in life span from the eradication and cure of many previously endemic diseases have generated new problems of exploding populations.

In our own country the social acceptability of the products of health R/D&I, whether in terms of new medical procedures, equipment or new drugs has been very high, at least until quite recently (when some of the undesirable side effects of the new drugs, contraceptives, treatments, etc., have begun to surface). The fact that the health industry has begun to be plagued by malpractice suits is less an indicator of falling confidence in health R/D&I than of mistrust of the delivery and care process.

4. Economic Factors

While economic factors certainly play a crucial role in determining the nature and operation of the entire health system, their impact upon medical R&D (by comparison) is relatively slight. This is so because the major funding sources for the field (the Federal government, 60%; the private, for profit sector, 30%) are relatively insulated from all but the most long term economic trends.

In general, the cash available to the Federal government is limited by the willingness of the Congress and Executive to appropriate funds. Although there are considerable pressures to limit the absolute level of spending, there is little or no economic reason to make cuts in one area over another. These decisions fall into the political arena rather than the economic; and as has been stated, health R&D is a safe political issue.

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The Medical Services Delivery System also has been relatively insensitive to economic pressures. This is somewhat more difficult to explain, but basically there are two prime reasons. Medical services delivery systems can be described, in general, as a geographically limited and controlled market with an inelastic demand. (Pipal et al. 1972; and Hepner and Hepner 1973). Only certain institutions and individuals are licensed to provide medical services; and entrance into the field is highly prescribed and controlled. The system is succintly described by Secretary of HEW Califano (1977):

> "We perceive the health care industry as virtually non-competitive. The features of the competitive market-place that have served our people so well in other industries -- to promote efficient allocation and utilization of resources -- are just about non-existent in the health care industry.
>
> The patient -- the consumer -- may select his family doctor -- but he does not select his specialist, his hospital, the services he is told he needs, the often expensive medical tests to which he is subjected. The physican is the central decision-maker for more than 70 percent of health care services.
>
> Increasingly, the patient -- the consumer -- does not pay directly for the service he (or she) receives. Ninety percent of the hospital bills are paid by third parties -- private insurance companies, Medicare, Medicaid.
>
> These reimbursement mechanisms usually operate on a cost-plus or fixed-fee-service basis, the most expensive and least efficient ways to function.
>
> Most public and private benefit packages are heavily biased toward expensive in-patient care.
>
> The unavailability of price and quality information keep the consumer of health care services dependent on the decisions of the health care provider, who plays a dominant role in determining demand for health services and whose financial well-being is determined by the price charged.

> The ability to restrict access to competitors -- hospital credential committees that can deny or delay privileges to Health Maintenance Organizations, for example -- provide special levers of market control.
>
> These are some of the dominant economic features of the health care industry -- features which provide many powerful incentives to spend more, and few, if any, incentives to spend more efficiently.
>
> We must face a basic fact: there is virtually no competition among doctors or among hospitals. And, just as important, there is precious little competition among pharmaceutical companies or among laboratories. For pharmaceutical and medical device and equipment research has become big business, with patent monopoly pots of gold at the end of the research rainbow."

The companies in the health care industry have found themselves, in the past, in the enviable position of being among the most profitable in the nation. According to Hepner & Hepner (1973):

> "There has been a spectacular boom for health goods since 1967...In fact, this era has been labeled a 'gold rush' by some; in 1969, $2.5 billion in after-tax profit was made by the industry. Stockbrokers advised their clients that they could see a steady growth pattern only in the health industry, as compared with other industries. Hospital supplies and medical electronics were the glamor stocks of 1969 and 1970. Some of these companies experienced a profit growth at the rate of more than 20% a year. Drugs, however, appeared to be one of the most profitable businesses of the health industry complex."

Working from such a financial base, the private sector at that time was in a position to afford significant expenditures for R&D, although present conditions may be less favorable.

The other 10% of the expenditures for health R&D come from not-for-profit sources, normally private foundations and the voluntary health agencies, HEW (1975 (a), (b)). Both of these sources of funds are quite sensitive to short-term swings in the economy. Voluntary health agencies depend primarily upon contributions from individuals to support both their intramural research and their sponsored extra-mural projects; and contributions vary quite directly with individual disposable income. Foundation contributions are dependent upon interest earned by the foundation's endowment. For the most part, endowment funds are invested in long-term bonds. The yield on such bonds in a given year directly determines the amount any given foundation will contribute to the support of research in the following year, HEW (1975b).

One further point seems worthy of note. Expenditures for health R&D are taking up an ever increasing share of the total Federal R&D budget (Table I). Because the growing concern for cost-control in all Federal programs, it is suggested that the medical R&D system is coming under closer scrutiny in the future.

5. Scientific and Technological Conditions

These are perhaps the most difficult factors to assess with respect to health R&D. The literal explosion of information within the past 25 years as well as the continued trend towards specialization in all parts of the health field makes understanding the "state of the art" a full time proposition. This poses considerable problems for the policy maker as well as the practitioner.

If, as has been asserted, the question for policy makers is not at what level to fund medical research but rather what research to fund at a given level, it can be seen why the rapid change in the medical knowledge base causes a significant problem. Unless the policy maker is a current specialist in a variety of fields, it becomes extremely difficult to do comparative cost/benefit analyses on research proposals. As such, developing a coherent, integrated research program becomes a most difficult task.

II. HISTORICAL DEVELOPMENT

The history of health research can be conveniently divided into three periods: pre-World War II, the War years, and World War II to the present. The periods parallel the introductory, transitional, and mature phases of development of the system. In general, the phases are differentiated by marked change in the funding and institutionalization patterns in the sector.

1. Pre-World War II

The National Institutes of Health had its origin in 1887 when a research laboratory was founded at the Marine Hospital, Staten Island, N.Y., to meet new responsibilities of the Marine Hospital Service. This was renamed the Hygienic Laboratory in 1891 and moved to Washington, D.C. Nine years later an Advisory Board was established for the Laboratory; this was later to become the National Advisory Health Council. In the same year, Congress gave the Service responsibility for control of biologics. In 1912 the name of the Public Health and Marine Hospital Service was changed to Public Health Service. In 1930, the Hygienic Laboratory was renamed the National Institute of Health. Congress authorized the National Cancer Institute in 1937 and the first research grants were made. In 1938 the National Institute of Health moved to Bethesda, Md. In this same year the National Cancer Institute awarded the first research fellowships. In 1944, the Public Health Service Act consolidated and revised existing public health legislation, and gave NIH general legislative authority to conduct research.

It can be stated with reasonable assuredness that this country had no integrated health research and development policy prior to World War II. From the later decades of the 19th Century through 1941, it was the private sector rather than the Federal government which supported most bio-medical research. Foundations such as the Rockefeller and Carnegie trusts invested large amounts in medical research during the first quarter of this century. In fact, by 1928 the Rockefeller Institute had a total endowment of $65,000,000; and its annual budget alone was many times that of the Federal government's. (Greenberg 1967).

During the late 1920's, however, the situation began to change. Public health and particularly the problem of cancer were becoming significant concerns. In fact, cancer was "costing the United States almost $800 million a year, destroying more than a hundred thousand lives a year and inflicting more suffering and agony upon the American people than all the other diseases known to humanity. (Cong. Record 1928). Between 1928 and 1930, the United States government took its first major steps on the road to becoming the primary support of biomedical research in this country. The Congress established the National Institute of Health as a division of the Public Health Service and appropriated three quarters of a million dollars to erect additional buildings to house the research effort of the Public Health Service.

However, this period was not without its problems. In particular, the question of who was to take the policy initiative in the national health R&D system was a thorny one. Initially, it was Congress rather than the executive that had shown interest in the public health domain. But with the onset of the depression and the election of Franklin D. Roosevelt, the situation changed. For the next three years there were proposals and counter proposals, power plays by various parties, and in general, confusion about what was happening. Largely through the efforts of then Assistant Surgeon General Lewis Thompson, a compromise was reached; this resulted in Title VI of the Social Security Act of 1935 which authorized expenditures of up to $2,000,000 annually for the investigation of "disease and the problems of sanitation." (Strickland 1972). These funds were placed under the control of the NIH and greatly enhanced its position in the field.

The final event of significance prior to World War II was the creation of the National Cancer Institute in 1937. As was previously noted, it was the cancer problem which had triggered much of the interest in public health during the late 1920's. From 1928 to 1937, numerous bills dealing with the support of cancer research had been sponsored in both Houses of Congress. However, the policy void during most of those years had been an adequate deterent to the passage of any one bill dealing with the issue. In particular, the executive was opposed to singling out cancer for special treatment. The issue came to a head in 1937, partly due to a massive public relations campaign aimed at raising public support for some kind of funding (e.g. Fortune Magazine, March 1937, carried an article entitled, "Cancer: the Great Darkness"). In an unusual move, joint House-Senate hearings were held on all the bills then under consideration which dealt with the cancer problem. A compromise was reached, and the National Cancer Institute Act was passed on July 23, 1937; the President signed the bill into law on August 5 of that year. The Institute was placed under the control of the National Institute of Health, thus further establishing that agency's position in the health R&D system.

The history of the National Cancer Institute is worthy of note in at least three ways. First, it exemplifies the workings of the pre-World War II policy formulation process for the health R&D system of this country. Political in-fighting, partisanship, turf protection, and ultimately compromise were the order of the day. These conditions remained permanent until the war effort was to force the country into a unified position. Second, it established the precedent of creating particular medical "institutes" to deal with specific diseases ("Categorical" Institutes). The obvious need for coordination of research effort was beginning to evidence itself, and the patterns of institutionalization which would dominate the field in the future were forming. Third, it firmly established the NIH as the controlling organization in the Federal Government's activities in the health R&D system. Although its position was to be challenged later, the NIH was destined to grow with each additional "institute" placed under its auspices. The National Cancer Institute was the inaugural step along that path.

2. 1941-1947: The War Years

Faced with the task of mobilizing the country for war, President Roosevelt soon recognized the almost critical need for a strong, centralized policy for medical R&D. The newly created National Defense Research Committee was quickly proving the benefits to be obtained from such an approach. It therefore came as little surprise when in July, 1941, Roosevelt created the Office of Scientific Research and Development (OSRD). Placed under the direction of Dr. Vannevar Bush, OSRD had two sub-components: the Committee on Medical Research (CMR) and the already existent National Defense Research Committee.

Initially, CMR was charged with "mobilizing the medical and scientific personnel of the nation ... recommending to the Director (of OSRD) the need for and the character of the contracts to be entered into with universities, hospitals, and other agencies conducting medical research activities, and submitting recommendations with respect to the adequacy, progress and results of research on medical problems related to the national defense." (Strickland 1972).

CMR did its job well, spending some $25 million between 1941 and 1947. Perhaps its most impressive accomplishments came in the area of "development" rather than research. Such discoveries as penicillin and blood plasma, which had existed as laboratory prototypes only at the beginning of the war, had been brought into mass production. They were widely available to the armed forces and on a more limited basis to the civilian population as well. Congress was greatly impressed; and with victory in the European theater virtually assured by late 1944, it began to investigate ways of continuing the centralized and highly productive medical research and development policies established during the war.

There were at least three separate proposals for how this might be accomplished. Vannevar Bush, as Director of the Office of Scientific Research and Development, felt that a unified approach to the problem should be taken and felt that all federally sponsored R&D (including medical) should be controlled by one agency. However, he was concerned that research and researchers not be overly controlled by the Federal bureaucracy. He therefore proposed the creation of a National Science Foundation as a semi-autonomous organization to disburse government research funds. A second proposal was to create a new separate, federal agency to deal strictly with matters of health R&D. This approach was suggested by a committee which Bush had created and charged with the responsibility of making recommendations concerning the continuation of federally sponsored medical research after the war. The third alternative was to allow the Public Health Service, and particularly NIH, to assume these responsibilities. With the end of the war in sight the unanimity of purpose concerning medical R&D policy quickly vanished, and a stalemate ensued for the next few years.

At approximately the same time, the Public Health Service had acted to strengthen its own position. In late 1943, it initiated legislation to revise and consolidate the many statutes under which it then operated. Passed and signed into law the following year, the Public Health Service Act of 1944 authorized that agency "to pay for research to be performed by universities, hospitals, laboratories, and other public or private institutions." It therefore was given powers roughly similar to those entrusted to CMR at the beginning of the War. The major difference was that NIH was to award "grants" while CMR had signed contracts.

By 1946, CMR was ready to close down its operations. However, the political debate on a national R&D policy agency was still deadlocked; and someone had to assume the administration of the remaining CMR contracts. Only the armed services and the PHS were legally empowered to do this. When the services declined the opportunity, the task fell to

PHS and more specifically to NIH, increasing its budget considerably. During fiscal year 1945, NIH let $180,000 in grants; 1946 saw that climb to $850,000 as the CMR money began to pass over; by 1947 it handled almost $4 million. With its expanded administrative duties NIH needed more personnel and office space. As a result, Congress increased the total NIH budget for fiscal 1947 to $8 million, up from $3 million just the previous year. Thus, before the political process could produce a solution, NIH had de facto become this nation's administrative agency for health R&D.

3. The Post War Years

By 1947 the broad brush strokes of the national medical R&D policy had been established. However, the issue of a total national health policy was still up in the air. Clearly, one was needed. There was growing public interest in and concern about this nation's health practices. An active and competent health lobby had developed and was pushing for major legislation on numerous fronts, the two most controversial of which were a national health insurance program and direct federal support of medical education in this country.

While these issues were generally viewed with favor by the public, there was one important organization which was flatly opposed: the American Medical Association. Vehemently opposed to any attempt to "socialize" medicine in this country, it lobbied in Congress and carried out a massive public relations campaign to persuade the public to support is position. Because the national health insurance program was such an integrated part of President Truman's proposed health legislation, the entire package was left in limbo. At the same time, public pressure for federal spending in health continued to increase. There was only one place for those federal dollars to go: Research and Development. By 1954, the NIH budget had skyrocketed to $71 million. At that point, the momentum of the system had been established and expenditures continued to rise.

At least in part, this was due to a general belief that if a little money did some good, more money did more good. The amazing success of the war time medical R&D operation had convinced people that with "proper funding, medical miracles awaited just around the next corner. When they were not immediately forthcoming, the policy response was simply to increase funding. Further, medical R&D had become a "growth" industry. More money brought in more researchers who needed ever increasing amounts of support. Thus, the basic character of the system was established and to a greater or lesser extent continues to this day.

A new dimension was added to the health R/D&I system in 1968 with the founding of the National Center for Health Services Research. The Center went through several reformulations culminating in Public Law 93-353, the "Health Services Research, Health Statistics, and Medical Libraries Act of 1974." This legislation authorized the National Center to undertake research, demonstration, and evaluation activities with respect to the delivery of health care. The concerns of the Center are how the health services delivery system is structured and how it operates and on its success in delivering health care to the public. It seeks to improve the effectiveness and efficiency of the system through an understanding of knowledge production and knowledge utilization behavior and through developing and evaluating new methods of producing, funding and providing health services.

Organizationally it is part of the Health Resources Administration within the Public Health Service in HEW. Its funding has fluctuated from approximately $75 to $95 million. Some of the general program areas are: quality of care, inflation and productivity, health care and the disadvantaged, personnel health, health insurance planning and regulation, and emergency medical services. A number of Health Services Research Centers have and are being set up. These consist of both "general" and "national special emphasis" centers (e.g., in health care technology and in health care management).

4. Health Delivery System

Some additional thoughts on the health delivery system are in order. It should be remembered that it is not a system that has been designed. It is rather a conglomerate of providers, consumers, organizations and finance mechanisms that has evolved over the past 100 years. One must understand also that the present health services delivery system is at least as "disease" centered as it is health centered. Numerous indicators point to this conclusion; but perhaps the most important is the manner in which the system allocates its resources. Approximately 40% of all expenditures in the field are for direct hospital services. (Knowles 1970). And the norms of the hospital have been dominated by a medical concept rooted in "curing diseases and disorders, not preventing them." (Zald and Hair 1972). Doctor's services, drugs, and dentist's services account for another 37% of total expenditures; and it seems reasonable to assume that the majority of these funds also is spent for diagnosis and treatment rather than prevention or health education. (Knowles 1970).

It is probable that this state of affairs resulted quite directly from the infusion of new technologies and practices into the services system during the later half of the nineteenth century. Coe (1970) states:

> "it can be argued that modern medicine began in the nineteenth century. This was the era, especially the later half, when a bewildering array of inventions and discoveries was made and used as auxiliary means of getting at the 'internal environment'."

Further, he links this development of new procedures and equipment to change in the orientation of the hospital.

> "Prior to 1900, most hospitals had the avowed purpose of serving all who sought admittance, especially the poor and the sick. With improved medical care and its attendant rise in costs, this goal was altered to those who applied for care but were not dependent upon public charity, and finally, hospitals were

> geared to cater to those who desire hospital treatment in preference to home care and who were 'abundantly able and willing to pay for treatment.'"

No conscious decision to center the system around diagnosis and treatment was ever made. Rather, economic necessities and the state of medical knowledge in the late 19th century combined to determine the basic character of the system. This state of affairs has not changed significantly. Coe continues:

> "the modern hospital has become the focal point of the community's health care. In part, this trend was stimulated by technological discoveries...More significant for contemporary medical practice is the development of expensive and highly complex diagnostic and therapeutic instruments, which only a large organization such as a hospital could afford to own and operate."

This particular organizational pattern has impacted the health R/D&I system in three ways. First, hospitals are the primary "customer" of the R&D system; because the hospital's concerns center on diagnosis and treatment rather than prevention and education, most R&D dollars are also invested in these areas. Second, hospitals are geared to high technology, complex solutions to health problems; their very reason for existing is to act as a technology center. Therefore, the R&D system has centered upon producing high technology answers to the questions under consideration. Third, and perhaps most important, these trends have resulted in a very high degree of functional differentiation/specialization. At the present time there are over 13,000 medical/health journals in print; and the vast majority of these are specialty journals. There is in fact not one health R/D&I system, but rather many micro R/D&I systems, each of which serves a different clientele and works in a different area. Except in so far as all segments are funded from the same source(s), these systems operate independent of one another, with little or no attention paid to the problems of integrating these knowledge sources for the individual practitioner. The "information overload" which results is one of the most pressing problems facing the health system as a whole at this time and is a topic requiring important policy consideration. (Rutstein 1967).

III. INSTITUTIONAL BASE

1. Structure of the System

The basic structural components of the field are funding sources, research settings, producers (some of whom also engage in R&D), control organizations, users, support organizations, and ultimate consumers. Basic research, applied research and technological development each have their own system of components; but for simplicity, structural components for all categories will be presented together, as is indicated in Figure 1.

While this certainly presents an oversimplified picture of the field, it does indicate the basic dynamics of the system. Funding sources provide the resources for all three categories of system operation. Applied research is funded by all four sources; technological development primarily by private industry; and basic research by government, foundations and the voluntary agencies. Researchers utilize these resources to attain the goals of their specific category and channel the results either to a producer (as in the case of pharmaceuticals), to users or to researchers in the other categories. Support organizations provide political, social and organizational functions, with the insurance companies acting to make adoption of sophisticated procedures and equipment possible by spreading the usually high cost effects over the entire population.

2. R/D&I Institution Characteristics

The vast majority of biomedical research is performed in seven institutional settings: universities (predominantly medical schools); private industry; federal research institutes; private research institutes; hospitals affiliated with medical schools ("teaching hospitals"); federal

Structural Components of the Health R/D&I Field

Figure 1

Funding Sources

Government (60%)*

Private Industry (30%)

Foundations (5%)

Voluntary Agencies (5%)

Researchers

Federal Institutes (8%)**

Universities (26%)

Industry (32%)

Hospitals (27%)

- -voluntary, state, local 34%)
- -Federal (30%)
- -medical School (36%)

Other (7%)

Producers

Pharmaceutical Firms

Hospital Supply Firms

Medical Electronics

Computer Firms

Etc.

Control Organizations

FDA

Users

Health Care Providers

- -physicians
- -dentists
- -hospitals
- -clinics

Ultimate Consumers

People

Support Organizations

American Medical Association

American Dental Association

American Hospital Association

Assoc. of American Medical Colleges

Council of Medical Socialty Societies

Blue Cross

Insurance companies

*percentage of support provided per annum

**percentage of system resources utilized per annum

Source of data: Derived from NIH Almanac 1974; (1) Resources for Health R&D Report No. 19--"Resources for Biomedical Research in Education," Nov. 1970; (2) No. 21--"Voluntary Health Agency Support for Health Research and Development," Sept. 1975; (3) No. 22--"U.S. Private Foundation Support for Health R&D," Nov. 1975.

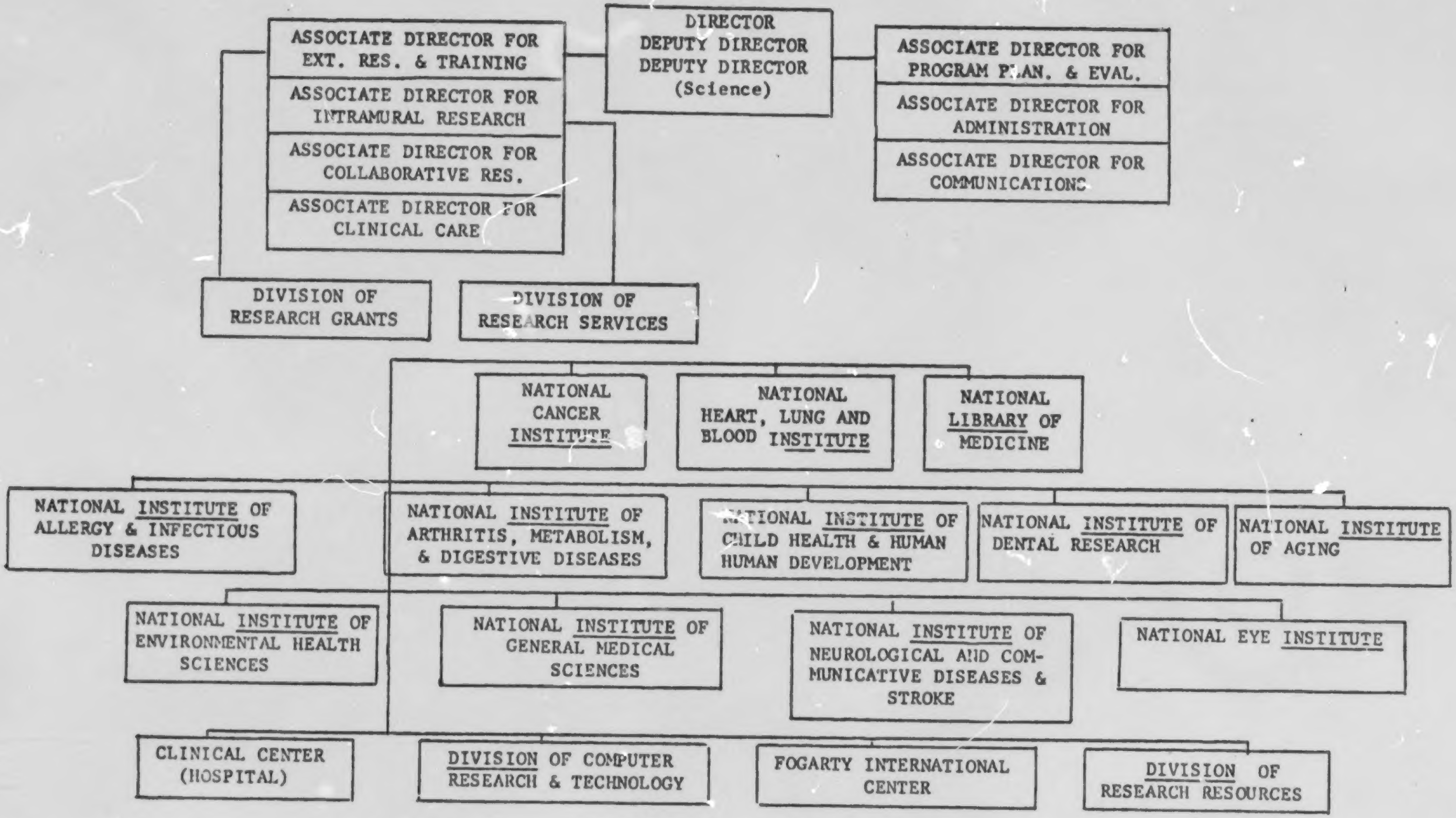
hospitals; state hospitals; community or public, non-profit, and for-profit hospitals. Given the evident diversity of these settings, it is somewhat surprising that the absolute number of institutions involved in research is not larger. For example, in 1967 only 524 out of 5,700 of this nation's hospitals had active programs in biomedical research, but only approximately 1,400 of these were over 200 beds. Fifty-one of all hospitals accounted for $136 million in expenditures--over two thirds of the total for this type of organization. (HEW 1970).

In 1970, this country had about 100 medical schools. If we combine those funds allocated directly to these organizations with those funds provided to their subsidiary teaching hospitals, another 36% of total system expenditures are accounted for. Therefore, over 40% of all expenditures in the field can be accounted for by less than 160 organizational units.

In terms of funding sources, the Federal government undoubtedly occupies the premier position in the field. Most federal funds not spent to support the government's own research programs flow through the National Institute of Health. Primarily these funds are used to provide grant monies to non-profit organizations and to private institutions working in research and medical education. NIH also supports the diffusion process in basic research by sponsoring the programs and activities of the National Library of Medicine.

NIH is comprised of twelve research institutes in addition to a common, central research hospital; a division of research grants for quality review of extramural grant activities; a research support division for its own intramural research activities; a division for extramural research resource provision; a division for international activities; a division of computer research and technology; and the National Library of Medicine with its own extension and grant activities.

FIGURE 2. NATIONAL INSTITUTES OF HEALTH


DIRECTOR
DEPUTY DIRECTOR
DEPUTY DIRECTOR (Science)
ASSOCIATE DIRECTOR FOR EXT. RES. & TRAINING
ASSOCIATE DIRECTOR FOR INTRAMURAL RESEARCH
ASSOCIATE DIRECTOR FOR COLLABORATIVE RES.
ASSOCIATE DIRECTOR FOR CLINICAL CARE
ASSOCIATE DIRECTOR FOR PROGRAM PLAN. & EVAL.
ASSOCIATE DIRECTOR FOR ADMINISTRATION
ASSOCIATE DIRECTOR FOR COMMUNICATIONS
DIVISION OF RESEARCH GRANTS
DIVISION OF RESEARCH SERVICES
NATIONAL CANCER INSTITUTE
NATIONAL HEART, LUNG AND BLOOD INSTITUTE
NATIONAL LIBRARY OF MEDICINE
NATIONAL INSTITUTE OF ALLERGY & INFECTIOUS DISEASES
NATIONAL INSTITUTE OF ARTHRITIS, METABOLISM, & DIGESTIVE DISEASES
NATIONAL INSTITUTE OF CHILD HEALTH & HUMAN HUMAN DEVELOPMENT
NATIONAL INSTITUTE OF DENTAL RESEARCH
NATIONAL INSTITUTE OF AGING
NATIONAL INSTITUTE OF ENVIRONMENTAL HEALTH SCIENCES
NATIONAL INSTITUTE OF GENERAL MEDICAL SCIENCES
NATIONAL INSTITUTE OF NEUROLOGICAL AND COMMUNICATIVE DISEASES & STROKE
NATIONAL EYE INSTITUTE
CLINICAL CENTER (HOSPITAL)
DIVISION OF COMPUTER RESEARCH & TECHNOLOGY
FOGARTY INTERNATIONAL CENTER
DIVISION OF RESEARCH RESOURCES

The medical profession, while largely personified in the users, is involved in and maintains strong controls over all phases of the R/D&I process. Whether the research is carried out in federal institutes, universities or drug companies the work must be ultimately evaluated and legitimated by M.D.'s. While much of the research may be conceived and carried out by chemists, biochemists and even engineers, the fundamental rate and direction of research is M.D.-determined, often leading to significant tensions and clashes between the Ph.D. and M.D. personnel (whose status is generally much higher). This infusion of the medical user profession into the research, development and evaluation phases even, for example, reaching into the control of support institutions such as Blue Cross, is a significant characteristic of Health R/D&I -- making a neat linear specialization description a poor model of the system. This issue is compounded by the fact that many innovations in techniques and even minor equipment will derive from the day-to-day experience of medical practitioners.

IV. GOALS, POLICIES, AND STRATEGIES

The goal of the total health R/D&I system can be described as the creation of the knowledge, techniques, and products necessary to improve the state of health of the population. This is to be done by prevention when possible and, failing that, by diagnosis, treatment and rehabilitation. However, to whatever extent the various functional stages of the system are discrete and independent, this overall goal becomes manifested in the more specific sub-goals and policies of each such discrete functional stage of activity. By discussing the goals and strategies of three significant functional stages of the system, the overall goals and policies can be inferred. The three stages to be discussed are: basic research, and applied research which map into our research feature; and technological development.

The first, but not necessarily the largest, category is basic research. Here the problem is to understand the basic functioning of the biologic and physiological processes. An example would be how genetic information is transferred from one generation to the next in the molecular structure of large protein molecules. This knowledge is then used to aid applied researchers in their attempts to deal with specific diseases. Diffusion is accomplished through journal publications, conferences, etc.

Probably the largest category of activity is applied research. Specific diseases are investigated either to isolate potential causative agents or to develop ameliorative techniques. The criteria by which a given technique is evaluated are based almost solely on effectiveness considerations. Because demand is not price sensitive, cost and efficiency are not vital concerns. Rather, the absolute probability of successful treatment (no matter what the cost) is of ultimate importance. The customers for the results of applied research are not health care consumers directly, but rather the practitioners in the field.

Physicians, hospital administrators, and public health officials make the ultimate decision on which products and services will be utilized by the consumer. The main diffusion strategy of this segment of the field, therefore, is to convince the individual health care provider that the innovation is more effective than whatever is in use at the present time.

Technological development is the next most active category of endeavor. It consists of research on ways to supplement, improve, or automate established techniques. Examples of this category are advances in medical electronics (such as intensive care monitoring equipment), infra-red mammography (for detecting breast cancer), the use of various radiation sources for therapy, and computer assisted health information systems. The major customers for these products are hospitals, clinics and research facilities. The major developmental strategy is to adapt existing technologies to specific health problems. The diffusion strategy consists of the effectiveness arguments as previously presented and what might best be described as a "prestige" approach. Hospital accreditation and standing in the field are closely related to the range and quality of hospital facilities. (Zald and Hair 1972). Therefore, the desire to "keep up with the Joneses" becomes an important motivating factor in the adoption of innovation.

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V. ADMINISTRATIVE PROCESSES

The environment of institutions in the health R/D&I system is typical of that faced by most R&D organizations. Uncertainty and decision making under conditions of partial information are the normal state of affairs. Therefore, management must remain flexible if it is to meet the demands of changing conditions. Furthermore, because a sizeable proportion of these organizations' employees are "professionals", it is not uncommon to find the dual ladder form of organization structure in use. This practice allows the scientist to advance in status within the organization without having to assume responsibility for administrative details. This seems particularly well suited to the health field because the preliminary stages of the R&D process must usually be performed under the supervision of the physician. It is, therefore, useful to have such an individual in a position of authority while having his/her administrative counterpart handle the details of operation. This does not imply that there is harmony between administrative and medical personnel. To the contrary, one of the central management challenges is the resolution of conflict and friction between these R/D&I system participants.

The administrative characteristics of funding sources are also important. The Federal government supplies over 60% of all funding for the field and faces an enormous control task. The sheer size of the Federal organization makes communication and coordination difficult and unwieldy. (Coe 1970). Even though the majority of funds are controlled by the National Institute of Health, other government agencies disburse almost a total of $1 billion annually. Under these conditions it is not surprising to find some duplication of effort and some inefficiency. Also, administrative costs for the field are increasing; this problem is particularly important for the voluntary health agencies where the majority of monies collected go for administrative costs. (Lasagna 1963)

The conflicts between M.D. and Ph.D. researchers has already been alluded to. The problems of interface management would tend to be critical but this is somewhat alleviated by the relatively close organizational proximity in which they often work. Nevertheless this is a major cause of friction in many health R&D laboratories.

Health planning, generally based on demographic, ecological, economic and legislative bases is a developed and growing area. Less evident is the type of technological forecasting known to industry. In health the role of the "health systems" expert based on experience in the field seems still to be the basis of much of the conceptualization and planning outside of the above mentioned disciplines.

By and large, projects tend to be relatively small. While a great deal of work may be going on, frequently in parallel and potentially pointed towards a single application, the large scale integrated project of the NASA Apollo variety, with thousands of people contributing small elements to a total system, is not part of the health R/D&I scene.

There has been some concern in recent years whether the proliferation of the disease-oriented, categorical organization of NIH was appropriate. It has, in the words of the President's Biomedical Research Panel, created two challenges to management:

(1) an ever-increasing span of control for the Director of NIH; and

(2) a need to assure that this structure does not limit interdisciplinary research at a time when all aspects of research whether fundamental or applied are increasingly interrelated.

The Panel recommended that if new programs were established or if existing programs were strengthened it should be done through the present Institutes rather than the creation of new ones. It went on to suggest that the Director of NIH consider the consolidation of related Institutes into

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larger units. It was felt that this would decrease the span of management.

One of the other organizational issues that the Panel looked into was the special organizational status of the National Cancer Institute. There was great concern when the National Cancer Act of 1971 was passed that the authority to submit its budget directly to the President would have a deleterious effect on the overall research management and success. Strickland (1972) comments on this:

> Organizational arrangements can affect policy outcomes, but the degree to which varying organizational forms affect the conduct of scientific research is not precisely measurable, especially if policy goals remain somewhat comprehensive and operational ethics remain constant. Thus it is entirely conceivable that the establishment of a separate cancer authority would not radically have changed the nature of the American bioscientific enterprise, even though it probably would have changed dramatically the present government research support structure. Whether or not the new cancer research money was finally housed in a new independent agency or remained within NIH, certain traditions would have remained the same: although much of the money would be spent for contracts, many if not most such contracts would be with academic institutions; . . . . The creation of an independent cancer research agency outside NIH might have made some marginal difference in the degree to which some researchers reordered the emphasis of their work. But historical patterns suggest the probability that, even if some scientists followed the new cancer money to a new agency most of them would change the titles of their proposed projects rather than the fundamental questions they wanted to investigate.

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VI. PERSONNEL BASE

The National Academy of Sciences/National Research Council completed a report in 1976 entitled "Personnel Needs and Training for Biomedical and Behavioral Research." They were given the job by Congress to establish the nation's overall need for biomedical and behavioral research personnel of all kinds. The preface describes the underlying difficulty of the study: "Central to all of these efforts is the fundamental issue of the degree or extent to which it is possible and useful to define and establish human resource requirements for increasingly fine fields of specialization within the biomedical and behavioral sciences." In the final analysis the personnel are the intermediate goal of research. The final goal is the generation of ideas and research that will result in improved health. "No calculus exists for describing relation of numbers and quality of people to numbers of useful ideas."

It is extremely difficult to estimate accurately even the total personnel base presently utilized by the health R/D&I system. As opposed to the aerospace industry whose activities are clustered in a relatively limited number of large organizations, health R/D&I takes place in many contexts and over a broad range of topics. As a result, health R/D&I is not grouped as a single area in any of the statistical summaries that are readily available. While quite accurate information on various sub-components of the field is available, total figures are not.

For example in 1967 state, local, and voluntary hospitals employed 21,823 persons in R&D. Of this number, 12,459 (57%) were classified as professionals. Also, these organizations had 6,178 principal investigators in their employ -- approximately 15% of the 42,000 total for the field. (HEW 1970). If we assume that these ratios hold constant across the entire R & D system, then approximately

150,000 persons were employed in 1967. Present estimates place the total number of professionals in the field at 85,000. (HEW 1973). (It should be noted that these numbers refer only to those individuals actually involved in the R/D&I process; other hospital employees and production workers in the for-profit firms are specificly excluded.)

We have already commented on the importance of the professionalism of health R/D&I personnel, whether these are in the KP or KU[*] dimensions of the system. In fact this very professionalism often makes it meaningless to attempt to separate these roles. Physicians in particular operate with great independence and are likely to create personal innovations, many of which are therefore never diffused. The professionalism, with its licensing and status differentials has its dysfunctional aspects. Without the proper legitimating characteristics few can hope to be allowed to contribute to the R/D&I process.

One personnel base difficulty of the health regulatory system and its interface with the research community is its lack of attraction for the best scientific minds of the country. As Berger notes:

> Regulation for health has not been a strong focus for best scientific minds in the country. Regulation is characteristically controversial, making it unhappy territory for traditional academics. It is seen to be heavily populated by lawyers and filled with political overtones. Those scientists who have approached have, on occasion, found themselves unwittingly surrounded by the turmoil of public controversy and emotion and badgering by the public press. Further, the quality of the scientific enterprise behind regulation in the past has not seemed particularly sophisticated or challenging--inevitably bordering on applied science. (The irony here, of course, is that it is precisely this sophistication of scientific insight that is needed in this area.) Finally, and perhaps most important in programmatic terms, is the perceived lack of research monies from the regulatory agencies. This, too, is a circular argument. The more that scientists absent themselves from the affairs of regulatory agencies, the less support these agencies will be able to gather internally for their own research and development program at the time of budgetary reviews.

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[*] KP: knowledge production. KU: knowledge utilization.

VII. FUNDING

Since funding has been reviewed in some detail in previous features a major restatement here would be redundant. Therefore in a brief summary we note that funding for the field comes from four main sources: the government, private industry, charitable foundations, and voluntary health agencies. The federal government supplies approximately 60% of all R&D monies, private industry 30%, and foundations and the voluntaries contribute 5% each. Total system expenditures reached approximately $3.5 billion in 1973 and have remained nearly constant since that time (correcting for inflation).

One significant aspect of the funding patterns for the field is the dominance of Federal monies. Not only does the Federal government supply the majority of all funds, but it is effectively the sole supporter of basic and clinical research. While certain specialized areas receive support from private industry (e.g. pharmacology in the case of the drug firms), most basic and clinical research is intended for a non-paying market: the practicing physician and technological development. As such, the Federal government is the only reasonable source of funds. Nevertheless the medical profession maintains a dominant influence on the direction and focus of this spending.

VIII. INFORMATION FLOW

With the exception of that work done in certain highly competitive sub-sections of the for-profit firms, information flow within the system is open and relatively effective. Over 13,000 professional journals act as relatively quick means of disseminating information. A National Library of Medicine was created by Congress in 1956 to act as a central repository and clearing house for information in the field; additional funds were appropriated in 1965 allowing this organization to finance seminars and lectures at various sites across the nation.

In addition to this formal information system, informal communication in the field is extremely high. Hospitals involved in research traditionally hold seminars and colloquia for their staffs. And, as previously noted, cooperation between different research cities working in the same problem area is common.

One problem concerning information flow is its sheet volume. The 1958 Cumulative Index Medicus listed 60,000 articles on health and medicine (Rubenstein, 1957). The number is approaching 300,000 annually. This literal explosion of research findings makes it difficult, if not impossible, for the conscientious practitioner to stay current in his own field, let alone related disciplines. Adding to this problem has been the development of the "specialty journals." These publications are intended for quite specific audiences; and, as such, the general practitioner or specialist in some other area may find them all but incomprehensible. An additional important new dimension to the processing and distribution of information has come from the growth of computer based information systems.

Some recent work in the area of knowledge transfer was done by the

President's Biomedical Research Panel when it looked into the process and time required for the transfer of scientific innovation. The panel looked at the results of two studies that measured the time it took a laboratory discovery to widespread clinical application. "Between the years 1951 and 1974 for the cases studied, a median duration of seven years characterized the period between the concept for the applied research and the application to clinical medicine." Further, it was the Panel's finding that the time for the transformation had shortened considerably over the years. It went on to point out that the "two factors that seem to expedite innovation were the availability of an adequate science base and the degree of interest shown by the research community, as indicated by the number of investigators working on the subject in parallel or in competition."

A Senate subcommittee on Health and Scientific Research was recently looking into the transfer of knowledge. As Senator Kennedy (1977) noted in his opening statement:

> We have seen in recent years an unprecedented explosion in our understanding of biology and of disease. The research community is often criticized for failing to 'transfer' this new knowledge rapidly enough from bench to bedside, from laboratory abstraction to practical application. This is the problem of 'technology transfer' about which we in the Congress have heard so much of late.

He went on to say:

> This alleged 'lag' in the translation of knowledge from bench to bedside is one part of the technology transfer problem. But there is another side to that problem, a dimension which also has its roots partly in the productivity of our research establishment. It seems that, while some new medical technologies lag in their translation from bench to bedside, others leap into application too quickly. With the quickening pace of biomedical research, we have seen a proliferation in the number and kinds of health practices and procedures to which patients are subjected. Some of these new technologies and practices, it seems, have found their way into widespread use before their efficacy and safety have been established by careful scientific testing. We have seen this aspect of the technology transfer problem in the example of the CAT scanner, which has come to symbolize the unplanned application of new clinical procedures in this country.

The CAT (computerized axial tomograph) was cited as an example of how technology development and use are influenced by a lack of governmental action at a 1976 Conference on Health Care Technology and Quality of Care. "The case of the CAT scanner for instance how a new technology can quickly become part of the mainstream of medical practice when no check points exist in either the development process or in its use in patient care." The problem results from the fact that those involved in producing and using CAT scanners are not required to evaluate their benefits in relation to other diagnostic tools, it is unlikely that they will carry out the kinds of studies that are needed to determine whether utilization restrictions are necessary.

The policy monograph went on to recommend:

1) An expanded role for the NIH to include responsibility for technology assessment through the establishment of a new Technology Evaluation Office in the NIH Director's Office.

2) That a new Health Technology Policy Office be established in the Office of the HEW Ass't. Secretary for Health.

3) The new policy board in the President's Office of Science & Technology should have two major responsibilities in the health technology area:
   a) The board should monitor the reorganization of the Federal government's role in health technology policy;

   b) Serve as a forum to help resolve difficult technology-related policy questions.

IX. INNOVATIONS

The life and death aspects of medicine have a significant impact on the characteristics of the innovations. Quality and safety are essential. Reliability is critical. Medical innovations are generally complex. The testing requirements add substantially to the costs thereby requiring broad scale application of innovations developed by commercial firms.

A discussion of the nature of the product at this point would be redundant. It has been implicit across the details of each of the features reviewed above. However it would be useful to enumerate some of the types of innovations that might be involved in the R/D&I process in health.

A complete listing of recent innovations in health R&D is clearly unfeasible; however, a representative sample is provided to suggest major thrusts in the field. As previously indicated, three major sub-sectors of the field can be delineated: basic research, applied research, and technological development.

Basic research leading to innovations occurs in most of the life sciences and some clinical disciplines. For example, an intensive study has indicated that some forms of cancer are viral in nature. As such, it should be possible to develop vaccines (an applied research activity) which would provide protection from these cancers. Another area of considerable interest is the operation of the autoimmune response. Understanding this process promises an increased ability to:

1) diagnose diseases more quickly and effectively,

2) control diseases that have been contracted,

3) lengthen the life and reliability of surgical implants.

Applied research focuses specificly on the clinical aspects of health care. Examples of this activity resulting in health care innovators include the recent development of a rubella vaccine, organ transplant techniques, and the continued exploration of a wide range of pharmaceutical agents (e.g. chemo-therapy for cancer, broad-spectrum and specific antibiotics, drug therapy for psychiatric disorders, etc.). Also developments in rehabilitation techniques including the use of mechanized prostheses would fall into this category.

The technological development area has provided a rich source of innovations. Medical telemetry has advanced significantly; the automated monitoring of vital signs in the intensive care setting, remote monitoring of vital signs from emergency vehicles, and the recording of cardiac functioning (by a device the size of a pack of cigarettes) during the normal work day of the patient are all recent developments. Sophisticated computer techniques developed by NASA to enhance the resolution of photographs taken by the Mariner series of space probes is now used to improve the quality of diagnostic x-rays. Infra-red techniques aid in the early detection of breast cancer. Automated processing of laboratory tests (e.g. by the SMA-12 blood analyzer) provide quicker, more accurate, more reliable and less costly diagnostic information to the physician.

Eventually the import and benefits of health innovations are enjoyed by almost all members of American society. The net result is longer and healthier lives.

X. NEED IDENTIFICATION

The need identification process for health R&D works on four separate levels, reflecting the three categories of activity within the system (basic research, applied research, and technological development), and a division in applied research between commercial and not-for-profit activities. In basic research, priorities are set by examining two factors: the present states of the art in biology and the physical sciences and the most pressing problems in clinical research. For example, theories had been advanced that the majority of cancers could be traced to genetic changes in the affected cells. Therefore, the process of cellular mutations whether caused by exposure to radiation, chemical agents, or viruses has come under close scrutiny. The need for this knowledge was evidenced by the consumers of basic research: the applied researchers. The fact that present knowledge of these processes was not equal to the task led to the research.

In technological development, needs are not identified so much as are potentials. Because most advances in this area are designed to replace, supplement, or refine existing products and techniques, the need for a new product is demonstrated by the fact that an existing product is outdated in terms of the state of the art. At this point, the problem becomes that of finding a new technology with the potential for doing a better job than existing technologies.

In applied research, two streams of need identification are evident: one founded in the not-for-profit exploration of clinical problems and the other in the private industry development of new means of treatment--principally pharmaceuticals. The not-for-profit clinical segment of this category uses the results of epidemiology and morbidity and mortality statistics to identify those health problems which affect the most numbers and cause the most suffering. Priorities are then established on the basis of this data. However, two other factors come into play. First, because virtually all of this form of biomedical research takes place in the large hospital/medical school context, problems amenable to handling within these facilities receive a somewhat greater proportion of attention than their incidence rates might warrant. Second, as noted, diseases which have great emotional impact for the public (e.g.: those that cause death) also are given higher priority than a purely rational analysis might dictate.

For-profit firms are faced with a considerably different set of problems. First, the effective product life span in the health area is decreasing. This means that a new product must pay back its R&D costs in a shorter period of time, or have a higher success rate. It must also offset the costs of many other products that, for one reason or another, fail to reach the market. This has put a premium on developing products which could penetrate the broadest based consumer markets (e.g.: wide spectrum antibiotics). In addition, the lengthy process of FDA approval of new drugs almost eliminates the ability of smaller companies to compete efficiently. The larger companies need a broader market to justify their investment. Second, these firms must convince providers that the new product gives a sufficiently greater therapeutic value than products presently in use to justify the risk of trying it. Like the technological development category, for-profit firms in the applied research category find themselves in a "substitution" situation. Coleman et al. 1966). Need assessment, therefore, comes as much from surveying the providers of health care as it does from noting the characteristics of the ultimate consumers. Again effectivesnss and profit rather than need in the health arena is of primary concern.

XI. GENERATION/RESEARCH

Most of health R&D has been, and will continue to be, based directly on the biological sciences. However, what is most impressive about the present state of the R/D&I system, at the research stage, is the degree to which other physical sciences and the social sciences have begun to contribute to the field. Many of the newer clinical specialties such as nuclear medicine and radiology are based as much on physics and molecular chemistry as on biology and physiology. In addition to this, increased concentration on problems such as alcoholism and drug abuse have brought social science results and methodology into the picture. And, as has been pointed out, the technological development category of health R&D is based almost entirely on the technology transfer principle.

In part these changes can be attributed to an expanded conceptualization of what is meant by health. Not so many years ago, we spoke of a medical system rather than a health system; and medicine has always been a disease-oriented profession (Coe 1970). Clearly, good medical care is an important component of any health system, but it is not the only component. Today health is no longer equated with medicine as this definition from the Constitution of the World Health Organization demonstrates: "Health is a state of total physical, mental, and social well-being, and not merely the absence of disease or infirmity " (Geneva 1958). This change in philosophic orientation has opened the doors for contributions from a number of the social sciences as well as from demography, environmental studies, and a host of other disciplines.

Another important aspect of research is the impact that new technologies have had on the methodology of health R&D. On-line and off-line computer systems, fiber optics, advances in bio-statistics, etc. have opened new avenues of investigation by providing the means to gather and analyze formerly inaccessible sources of data. Also, increased interest in "environmental" health problems has taken some research out of the laboratory and into the field.

In short, there has been a continued differentiation of the field. On the one hand, investigators are exploring the physical and chemical processes upon which biology and physiology ultimately rest. To do this, they utilize costly, scarce, high technology equipment such as the electron microscope. On the other hand, a renewed interest in the holistic aspect of humanity and health has lead the health researcher out of the lab and into the field. Still a third group concentrates upon adopting existing technologies to health/medical problems. What is not evident in the system at the present time, and is therefore an important policy issue is any conscious attempt to integrate the findings of these various groups and establish priorities among them.

As indicated, this work of research is to be found going on in a variety of institutional settings. These range from the federal institutes largely at NIH; the university medical schools, hospitals and departments of biology, bio-chemistry etc.; in industry at drug companies, medical equipment and instrument manufacturers, supply companies; and in general hospitals. To this must be added the work of independent physicians, studies of human factors and biological phenomena, etc. in such agencies as National Aeronautic and Space Administration, Department of Defense, and so on.

XII. DEVELOPMENT

The development phase of health R/D&I is of central importance to the system. In the research stage, experimental data has been gathered using principally animals in experiments. Full scale development, however, is the stage at which the experimental results are interfaced directly with the patient. In the development stage, the stakes are human life and welfare. In particular, the probability of unanticipated side effects poses a great problem. Also, long term secondary effects must be considered. It therefore comes as little surprise that this phase of the R/D&I system is the one that comes under the tightest regulation and control both by the profession itself and by the government.

One of the areas of continuing conern in the research and development system is the question of the appropriate amount of testing of a new drug or device before it is approved for distribution. There are strong countervailing forces at work. Naturally the pharmaceutical industry is anxious to move the product to the marketplace as expeditiously as possible. In addition, the medical profession wants the most up-to-date treatments and drgus available for their patients as soon as possible.

The opposing forces are twofold. The public is generally concerned that unsafe drugs not be allowed on the market but their concern is general and may or may not be represented through consumer groups. The highly scientific or technical nature of the subject matter usually forces the issue back to the biological scientists at the Food and Drug Administration. Indeed the FDA has an unenviable, thankless job in the process.

When Charles Edwards was commissioner of the FDA he noted:

> It's a particularly difficult environment for the Food and Drug Administration because in a sense, we're in the middle.

> We are on the one hand, criticized for being "soft" on the industry and on the other, called repressive, the enemy of free enterprise: on every major decision, we are accused by some of acting too fast without sufficient evidence, and by others of acting too slowly and too timidly to prevent unnecessary harm. We're expected to deliver on the promises to complete safety made by others but when the time comes to take action we find ourselves standing alone. We have had very little support and understanding from the medical and scientific community.

One would assume that, in addition to the pre-marketing research that the Food and Drug Administration performs significant post marketing surveillance of new drugs. This is not the case. Berger (1976) points out why:

> A major consideration is that of good "denominator" information. That is, in order to make observations on an exposed population (exposed, that is, to a particular food preservative or tranquilizer, for example), there must be on hand some information that would set apart or identify the exposed population. In most cases, the identification and followup of a group of persons known to have been subject to specific exposures are exceedingly difficult. It is possible with prescription therapeutic drugs--partly because the very act of prescribing is a kind of accounting system. Yet, even here, the problems of surveillance have appeared enormous and very little drug surveillance in any rigorous sense is traditionally carried out. The experience of the Food and Drug Administration in its attempt to carry out postmarketing surveillance of adverse drug reactions from among drug-taking patients has been exceedingly discouraging --principally because of the very difficult task of identifying with reasonable certainty those persons who are, in fact, taking particular drugs.
>
> This is vital information. Without it, observations on human subjects cannot be compared with known, unexposed, or controlled groups and it becomes essentially impossible to interpret the observations. The National Academy of Sciences acknowledged this difficulty in their review of adverse drug-reaction reporting systems. In fact, the only really reliable information collected after marketing has begun on previously unsuspected adverse reactions from therapeutic drugs has been from carefully controlled intensively monitored, in-hospital studies.

It should be noted, however, that the Food and Drug Administration does have significant leverage in the prior approval process. The General Principles of "Good Manufacturing Practices" give the FDA the duty to insure the safe and efficacious production of drugs. The FDA can test a plant's control system, sterilization procedures and even the room layout.

The main site for development in the form of both applied research and technological development is the medical school/teaching hospital. The developmental activities associated with applied research must be carried out in the clinical setting, and researchers at these institutions have a ready supply of subjects as well as the necessary back-up services and facilities. Subjects usually, though not always, come from the ranks of the welfare patients. Although these individuals have the right to refuse such treatments, reasonable questions could be raised regarding whether or not they have sufficient knowledge to make rational decisions.

Technological development also centers its pilot testing operations in the medical school/teaching hospital context. These institutions are geared to innovation. In addition to this, they are relatively more familiar with high-technology, advanced state-of-the equipment and favored by pharmaceutical companies because of their high prestige. Also, these institutions usually have the resources necessary to obtain the more esoteric products and the consumer base to make use of them.

The Forward Plan for Health for FY1978-82 of the Department of Health Education and Welfare speaks very cogently and honestly to the issue of our knowledge of generation and the value of technology in health. In its broad analysis the report notes: "The role of research in the generation of new knowledge continues to be a poorly understood phenomenon, particularly the way in which new knowledge is aggregated and brings about often subtle changes in clinical practice over time."

In speaking specifically of the role of technology in health care the report states: "Although there are existing technologies which, coupled with the appropriately trained manpower, can have a salutary effect on health care costs, it also now seems clear that widespread dissemination of certain technologies at every level of the health care system may not always be an unmitigated good."

In a recent speech Commissioner Kennedy of the Food and Drug Administration (1977) recognized the agency's role in the process of transferred technology.

> This legitimate role involves a more effective exercise of what has become FDA's main function in our society: As a technology transfer regulation.
>
> During most of FDA's existence it acted primarily as a kind of detective, ferreting out transgressions, prosecuting the transgressors, and eliminating the fruits of their iniquity from the marketplace.
>
> While we still stamp out quite a lot of sin, we increasingly have also become a major control point in regulating the movement of new health ideas and technology to the consumer.

Commissioner Kennedy also responded in this speech to the issue of an American "drug lag" by citing a number of drugs and harmful agents that did not reach the American public (like Thalidomide). He did admit, however, that

> ...by and large it does take longer here than in other advanced nations to approve a new drug, although we've taken a number of steps to speed this particular element of technology transfer. These include prior agreement about study design, sequential review and approval of data, and other steps aimed at eliminating unproductive and inflexible procedures. We also are supporting legislation to remove all scientific data re-

lated to the safety and effectiveness of drugs from concealment as trade secrets.

Even with these changes, accomplished and potential, the process of demonstrating safety and effectiveness prior to marketing may still move at a more deliberate pace than in certain other nations. This bothers me--just as it bothers some physicians, and all drug sponsors. . .

The answer is to look for ways to gain speed without loss of quality. And there are only two points at which to get it--before marketing; or afterward.

Except in rare cases where an 'imminent hazard' is deemed to exist, it is easier for FDA to do almost anything than to get a questionable drug off the market after it has been approved.

Because this is so, our only responsible course is to take extra care in the approval process. To the degree that such care entails a time penalty, that penalty could be eliminated by appropriate adjustments at the back end--at the point of removal.

FDA has already taken the initiative in suggesting a mechanism to accomplish this--an additional phase in the approval process, during which a new drug would be limited in distribution, controlled in application, and susceptible to rapid pullback if anything disturbing is learned.

But we also ought to do much better about recognizing problems during the period of full clinical use. Some critics, pointing to the systems operating in Finland, Sweden, Great Britain and other nations, have cast us as a kind of underdeveloped nation in regard to drug experience reporting, particularly adverse reaction experience. Although this conclusion is somewhat exaggerated, there is no doubt that the process in other nations is formalized, routine, and effective. The fact that these nations have such systems provides a key element in their system of rapid premarket approval.

XIII. PRODUCTION

Production activities in the health industry can be subdivided into the manufacturing of supplies and equipment and the rendering of direct service to the consumer. In both cases, quality control is the primary issue of concern. Governmental regulation has traditionally centered on the manufacturing subdivision through agencies such as the Food and Drug Administration. However, this situation may now be changing. In recent years we have seen the establishment of Professional Standards Review Organization to examine hospital practices. Also, organizations such as the American Hospital Association have traditionally established industry-wide standards for the equipment utilized by their member institutions.

It should also be remembered that the health industry is one of the most labor intensive in the country. Even in the high technology hospital setting, the majority of incurred costs are for manpower. Therefore, the system should, in theory, be relatively flexible in terms of adopting innovation (e.g. it is as easy, physically, to administer a new drug as an old). However, this discounts the psychological readiness of system members to adopt innovation. A serious concern for the health R&D system is the fact that provider institutions, in light of increased governmental regulation and consumer activism, may well be becoming more conservative in their response to innovation.

Drug manufacturing plants are operated along much the same lines as most production shops that combine both mass-production and small batch lots. Requirements for quality control and hygiene are, of course, very stringent. Laboratory and various types of hospital equipment are manufactured in characteristic electrical, electronic and machine plants. At this point it becomes difficult to draw sharp lines between for example, the electrical and health equipment industries.

The pharmaceuticals industry is one of the major segments of the industrial sector. It is international in scope, with major multinational corporations based primarily in the U.S. and Europe. Companies tend to emphasize, in varying degrees, "ethical" as opposed to the over-the-counter consumer drugs that can be purchased by the general public. Recently, there have been considerable pressures and constraints on drug manufacturers resulting from the activities of FDA.

Hospitals, clinics etc. have also been thought of as a part of the health care delivery (or production) sub-system. Over the years these have grown enormously in complexity and in the sophistication and capital investment of the equipment and facilities utilized. This has been one major factor in pushing up costs. Another has been the increased costs of the labor and professional factors. Altogether, the rising and by now very high cost of hospital care has been a major social, economic and political issue.

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

The health industry has experienced an unprecedented growth rate since World War II, and, at least for now, this remains high. What would occur should any of the national health insurance proposals before Congress be passed, remains to be seen. Dramatic drops would seem unlikely. Therefore most categories of health R&D are facing a large probably expanding market where new products are more likely to be diffused and absorbed than they would in a small or contracting market.

However, two previously mentioned trends pose serious challenges to the system. An increase in risk avoidance behavior on the part of health service providers could mean longer testing periods and the need for intensified sales efforts, while the growing interest in environmental and preventive medicine may require firms to diversify their activities into unfamiliar areas.

The pharmaceutical industry is the mainstay of the applied research, for-profit category of activity. As such, examining its marketing characteristics/problems should provide some insight into overall system functioning. The drug market is extremely competitive and somewhat volatile. Leaders in the field have made innovation a way of life. They spend large amounts on market research and advertising principally for over the counter items. Also, an impressive sales effort is evident in the realm of prescription drugs. All pharmaceutical firms employ large sales forces of "detail men." The job of the detail man is to visit the individual practitioner, provide samples of new products, explain their use and advantages over existing products, and convince the physician to undertake a trial usage of the product. The major problem facing the detail man, therefore, is to convince the physician that he/she should take the time to become sufficiently acquainted with the new product.

Another factor which influences the marketing strategy in pharmaceuticals is that the practitioner is almost exclusively dependent upon the producer for information concerning a new drug. The large amounts invested in research have paid off handsomely for the drug companies, and the rapidly accumulating body of knowledge about drugs and their effects has led to an increased tempo of new discoveries (Coe 1970). Each new product which comes to market is complex and relatively individualistic, requiring considerable sophistication and expertise for effective use. In addition to this, the overall use rate of drugs, both in number and volume, has increased sharply; in part this has been due to an increased emphasis on the treatment of chronic diseases which usually require extensive chemotherapy to stem the advance of the disease. These factors make it extremely difficult, if not impossible, for the physician to stay truly current in the field.

As a result, physicians have become more and more dependent upon the detail men and the suppliers' abstracts, etc., as a source of information about advances in the field. One study indicates that the detail man is by far the most important information source about new drugs utilized by the physician. However, the decision to adopt or not is strongly influenced by the physician's close colleagues. (Coleman et al. 1966). The situation is further complicated by the practice of using proprietary "brand" names for drugs rather than their longer generic or scientific names. With the physician's performance coming under closer critical scrutiny by both the government and the patient, the practitioner is becoming more wary of new products and the information he/she receives about them. This may dictate a considerable change in the marketing strategy of the field.

Marketing of drugs to physicians represents one discrete segment of the overall health market. Of equal concern should be the strategies and characteristics of the health market with respect to the diffusion of innovative facilities and equipment. The adoptors of such innovations are usually hospitals. With respect to the adoption behavior of hospitals, Russell and Burke (1975) were able to document the rate of adoption of several different innovative facilities and equipment by hospitals of various sizes and types of control (public vs. private). Their conclusions indicated that size was a far more determining characteristic in adoption in that large hospitals were almost exclusively the innovators and early adoptors. From the larger hospitals, the innovations diffused to the smaller hospitals over varying periods of time.

While interesting, if not surprising, such conclusions do not yet describe the marketing characteristics of the health services field. Of more importance would be information describing the adoption-decision processes used by such institutions. The same authors (Russell and Burke), however, concluded that little is known about the adoption motives, or processes, of hospitals. Such information would be critical to our understanding of the Health R/D&I system if we accept the feasible premise that the system has somewhat distinct market characteristics, as might be indicated by our earlier comments regarding the general lack of sensitivity of the health sector to economic fluctuations.

If the health innovation adopters are not sensitive to traditional market incentives, then it should be determined exactly what incentives do sensitize them. Again, Russell and Burke suggest some possibly important factors, including: local environmental characteristics, accreditation criteria, organizational ability to procure available funds, federal funding "guidelines", and others. Without suggesting too much comparison, it can be noted that some of these characteristics were observed to be important adoption-behavior determinants in the Radnor (1975) study of the Law Enforcement R/D&I system.

For our discussion here, it can only be concluded that the market characteristics for the diffusion of innovative equipment and facilities for hospitals are not understood sufficiently well, other than to postulate that the traditional market model is inappropriate.

XV. ACQUISITION

The characteristics of the acquisition process are most relevent to the technological development category of health R&D activity. Most sales for these products are concentrated in the hospital sector; and, as such, those factors impacting the willingness or ability of these institutions to acquire new equipment are of central importance.

There are four factors which contribute to the acquisition decision: need, present services structure, status, and availability of funds. Need assessment is based on the characteristics of the population served by the hospital. Thus many urban centers with their large populations and higher birth rates than the country as a whole make great demands on pediatric facilities such as nurseries for premature infants. Although a hospital may have all the facilities it really needs, these facilities may be outdated. Therefore, the decision to acquire replacement units will be based on the state of its present services structure. Peer pressure or status play the major role in the acquisition of new, "cutting edge" technologies. Most of these products are relatively low capacity and capital intensive; therefore, purchase is hard to justify in terms of consumer need. Second, financial donors are more willing to contribute to an institution that is a "leader" in the field.

The availability of funds has, in the past, had a greater impact on the timing of acquisition than on the decision to acquire. Federal monies were widely available to upgrade present facilities, add new ones, and increase the capacity of the hospital. However, this situation changed significantly when in 1966 Public Law 87-749*, Comprehensive Health Planning (CHP) Act, was passed. This legislation created a series of state-wide health planning groups ("A Agencies") and subsidiary groups ("B Agencies"). These groups had the power to control the flow of federal funds into the geographic area for which they are responsible. Composed of both consumer and provider representatives, the CHP agencies were charged with the task of matching consumer needs with available resources, and recommending what additional resources might be necessary. Therefore, although funding for these types of projects increased, the availability of the funds came under tighter control.

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*This has more recently been modified in a new law PL93-601.

With respect to the acquisition of innovative hospital facilities, (e.g., diagnostic radiology, and intensive care units), Russell and Burke (1975) confirmed that large hospitals generally are the innovators and early adoptors, with the innovations diffusing to smaller hospitals, as needs and funds become available.

Perhaps of more significance to our consideration of the acquisition process is the conclusion that little is known about the adoption-decision process of hospitals. More information is needed to answer questions such as who is involved in the acquisition decisions, how much technical vs. administrative input is represented in the decision, what is the impact of budgeting and purchasing procedures, where does the interest in the innovation originate in the hospital, what are the characteristics of innovative hospitals, etc. Schermerhorn (1975) has raised the issue of cooperation between hospitals as a factor influencing the likelihood of their acquiring specific facilites, by making it feasible for smaller institutions to acquire such frequently expensive but infrequently utilized equipment.

XVI. IMPLEMENTATION/UTILIZATION

Since one of the prime driving forces for adoption of an innovation is status, the very existence of a new product or technique creates a demand for it. As such, the level of direct, formal coordination between the health R/D&I system and the health services system tends to be low. To be sure, the guidelines and standards set by government regulatory agencies and the health field's national representative organizations (AHA, AMA, etc.) provide some formalized feedback. But for the most part, this feedback acts as a quality control measure rather than as input into the planning process. Therefore, that integration which does take place between the R&D system and the user depends more on informal information channels than on formal ties.

There are a number of individual, professional and structural issues that impact implementation. The professional status of the physician is of central importance. Besides generating a profession-based form of chauvanism that limits inputs from non-medical sources, the issue of status creates related systems level implementation difficulties. The medical staff at hospitals maintain a high degree of autonomy among specialities and from the administrative arm which constrains coherent overall systems level innovation programming tied to resource availability and planning. Relatedly, physicians may act to acquire expensive and sophisticated equipment not critical for diagnosis or treatment, therapy artificially increasing the rate of utilization (Rubenstein and Geisler 1975). Malenbaum (1971) has commented that there may not be a close relation between the acquisition of new sophisticated equipment and the quality of health care. The individual productivity of the physician as well as the physical risk aversion, given the often critical nature of the application for life, may further act to constrain potential implementation. This may be especially the case where significant retraining may be required to properly utilize new technologies.

Two distinct contexts for implementation/utilization can be delineated within the services system: the large, urban hospital (with or without a medical school) and the small, rural hospital. (The adjective "small" is defined as 100 beds or less.) It should be remembered that the majority of hospitals in this country fall into the latter category (AHA 1974). The characteristics of these institutions, therefore, have an important impact on the absolute level of acceptance exhibited by the service system towards innovation.

Virtually without exception, innovations are adopted more readily and sooner by the urban hospital than by its rural counterpart. There are three factors which account for this difference: the availability of information about the innovation, the market/resource structure facing the institution, and the psychological preparedness of decision makers to support innovation.

Availability of information is directly related to the communication patterns evidenced by the field; and, because formal integration is relatively low, those organizations that have the highest degree of informal interaction with the R&D system are the ones with the most information. The medical school/teaching hospital is the ultimate example of this with both R&D activities and implementation/utilization occuring in the same organization. Other large, urban hospitals may also house research -- and even if not, they are certainly familiar with hospitals that do. Further, city-wide hospital associations often provide a clearing house for a variety of information dealing with both administration and operations.

By comparison, rural hospitals, in relative isolation, are out of the mainstream of research and rarely come into direct contact with organizations in the stream. They must depend on state-wide hospital and the A.H.A. to provide them with information which may or may not be suited to their particular needs/interests. Furthermore, organizations within the health R/D&I system have not invested much marketing effort on these organizations, probably because they perceive little or no potential in the rural hospital market. As a result, the rural hospital is usually the last to know about an innovation; and even then it will receive only fragmentary information.

Further, the psychological preparedness of decision makers to support innovation is an extremely important factor. The administrators of urban hospitals tend to be highly educated, mobile, and cosmopolitan in outlook. Often, they have received degrees from special graduate programs in hospital administration in first rank schools. The administrator of the rural hospital, by comparison, has a much more varied and less academic background. A recent survey or rural hospitals in Southern Illinois (Pipal 1975) found examples of administrators who were also registered nurses, X-ray technicians , and laboratory technicians (and in one case, all three!). Less familiar with advanced technologies and the role of R&D in the overall health system, they tend to be more skeptical of those innovations that do come to their attention.

In addition to this, rural hospital administrators tend to remain with the same organization for longer periods of time than do administrators of urban hospitals. This can lead to significant emotional investment in the organization as it exists. This, in time, usually leads to increased resistance to innovation (Gardener 1968).

XVII. SUPPORT SERVICES

The support prerequisite for bio-medical research varies with the area under investigation and the catagory of R&D activity engaged in basic research, applied research, technological development. In almost all instances, basic support services and materials are available and not terribly costly. For example, in bacteriology, the basic requirements for research are lab space, an incubator (for cultures), cold storage areas to maintain perishable supplies, an autoclave for sterilizing instruments and containers, and basic chemical stocks. Also such standard equipment as microscopes and balances are required. In those few areas where high technology has become extremely important (e.g. cellular studies using the electron microscope), it is not uncommon for the research organization to employ its own maintenance staff. In general, external support systems play a very small direct role in most health research.

Of considerably greater importance are the interdependent and supporting roles that components of the health R/D&I system play for each other. Basic research supplies the specific information necessary for applied research; the technological development catagory produces the specialized instrumentation necessary for basic research; etc. Even within a given catagory, different research centers will often perform support functions for one another. For example, in virology a given cell line will be maintained at three or four different laboratories. Therefore, should some accident occur which destroys the cultures of one lab, the others can provide replacements with no loss of continuity.

In addition such organizations as the American Medical Association and the American Hospital Association play important political and economic roles in supporting the health care system. The American

Research Association is directly involved as a participant in the R/D&I system. Blue Cross, Blue Shield and various insurance companies play an important financial role in the R/D&I system that makes feasible the utilization of expensive innovations by spreading the cost over a large base.

XVIII. EVALUATION RESEARCH

The President and the Congress have taken a more active interest in the evaluation of the state of biomedical research in the past several years. The President's Biomedical Research Panel (1976) was charged with the mandate to review and assess the conduct, support, policies and management of biomedical and behavioral research as conducted and supported through the programs of the NIH and Alcohol Drug Abuse and Mental Health Adminstration. In addition, the Congress mandated National Commissions on Diabetes and Arthritis to study these diseases. These commissions have been helpful in focusing public attention on the diseases and useful in coordinating the attention of the research community on the problems. They have also created serious budgetary imbalances within and among the institutes as there have been no additional funds appropriated for research in diseases other than the favored diabetes and (to a lesser extent) arthritis.

Different facets of the evaluation process have been discussed throughout the body of this examination of the health R/D&I system. The most notable feature of the process is that the criteria for evaluation have tended to center almost exclusively on effectiveness, with little attention paid to the cost/efficiency of treatment. This was explained as being due to (1) the philosophical basis of Western Medicine which places a premium on individual life, and (2) the fact that third party payors have, until recently, shown little interest in cost control.

Another aspect of the evaluation process which should be considered is its "phased" nature. At each step in the research, development, adoption, utilization sequence, different and independent evaluations of an innovation take place. Control/evaluation of the research phase lies primarily in the hands of the researchers themselves.

Standards for appropriateness of research topic and methodology are set by the field.

During the development stage, the Federal regulatory agencies and the national health representative groups evaluate products in terms of minimally acceptable standards of performance. In general however, these standards pose few operational problems for the system. Most products which survive the field's own rigorous testing require little or no modification to meet government specifications.

A more critical test for the innovation occurs during the early adoption phase. At this time, health care providers perform their own, informal "test piloting" of value over existing products, ease of use, and re-training/re-education necessary for large scale implementation. Because many of these evaluations must be based on subjective information, the R/D&I system has little control of the process.

During full scale utilization, the innovation is not evaluated so much as is the practitioners' use of the product. Professional standards review organizations (PSROs) and utilization review boards (URBs) are more interested in the proper use of all available facilities, whether recent innovations or not. However, if the R&D system has not provided adequate information to users concerning a new product, such organizations as PSROs and URBs are likely to pick it up. This will reflect negatively on the particular organization introducing the innovation, and could cause that organization to lose credibility in the eyes of the intermediate consumer.

XIX. RESEARCH ON R/D&I

To date, there has been little or no empirical research done on the health R/D&I system of this country. While many organizations collect statistical information on various components of the field, overall totals are difficult to obtain. In addition to this, analysis of these partial statistics is often implicit and subjective with little consideration given to the comparability of methodologies. In short, our knowledge of the health R/D&I system is based more on opinion than it is on fact.

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CHAPTER SIX

THE R/D&I CONTEXT IN THE CRIMINAL JUSTICE SECTOR

The major contributions to this chapter were provided by Robert H. Howard and Raymond J. Buckley.

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INTRODUCTION

This report will utilize the CISST contextual analysis framework to describe the R/D&I system of the criminal justice sector. The National Institute of Law Enforcement and Criminal Justice (NILECJ) is the key agency in the R/D&I system in this sector and will receive much attention in the following analysis, as will its parent agency, the Law Enforcement Assistance Administration (LEAA). While NILECJ and LEAA will be discussed most often in their current organizational forms, it should be recognized that the Attorney General has just* recommended to the President a major reorganization of the agency. The reorganization, if accepted, would combine research in a criminal justice function (such as corrections) with action programming for that function. This reorganization would have the effect of facilitating the flow of the R/D&I within sector functions (police, courts, or corrections), but the effect of a more system-wide approach to criminal justice is somewhat problematic. Other proposed changes would include financial incentives for sector institutions which adopt research-proven programs which should encourage the utilization of innovations. The following analysis will start with a description of the criminal justice sector. Then, the nineteen points of the contextual analysis framework will be utilized to analyze the R/D&I system of this sector.

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*December 1977

THE CRIMINAL JUSTICE SECTOR

The sector of interest in this paper involves criminal justice -- a field of interrelated activities/institutions (identifiable as such for practical purposes) which is responsible for maintaining law and order in society. The boundaries will be drawn at one end by excluding the makers of the laws which are being enforced (legislators) and at the other end, the clients served by the system (criminals, victims and the general public). The functions of the criminal justice system include:

- Prevention functions (e.g.: patrolling, raising community awareness)
- Adjudication functions (e.g.: prosecution, defense, interpreting the law, judging guilt or innocence)
- Disposition functions (e.g.: jails and prisons, community residential programs, probation)
- Rehabilitation functions (e.g.: counselling, assistance in job finding, vocational and educational programs)
- Reentry functions (e.g.: parole)

I. ENVIRONMENT

The criminal justice system (like any system) exists within, affects, and is affected by its environment. The following analysis will discuss the interaction of the criminal justice R/D&I system with its environment including: political factors, ethical considerations, economic factors, social cultural norms, related disciplines and institutions affected by criminal justice R/D&I.

1. Political Factors

Criminal justice agencies exist at, and are affected by, all levels of government. For example, in enforcement there are: federal agencies such as FBI, DEA, and the Treasury; state agencies such as a highway patrol or a state bureau of investigation; county agencies such as sheriff's Police; city agencies such as local police departments* (city police). The heads of the agencies in the criminal justice system are either appointed by elected officials or must stand for election themselves. This situation subjects these agencies to political pressure. The public's fear of crime accentuates this pressure.

Two effects of the political environment are (1) resistance to innovations which cross jurisdictional lines, and (2) pressure on the R/D&I system to be accountable for the reduction of crime.

Regarding resistance to innovations which cross jurisdictional lines, an example may be a diversion program (treatment rather than trial) which requires the cooperation of the police and the State's Attorney. It may never get off the ground in a given instance when, for example, the participants are from different political parties and want to set up independent programs. Judges often resist involvement in cross-jurisdictional projects due to possible violation of the separation of powers.

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*There are also non-governmental agencies such as private security firms; security departments of large firms or of a university; etc. However, we shall in this analysis focus on criminal justice as a function of government.

2. Ethical Considerations

Since the criminal justice system operates on human beings in a context where the issues of laws and rights are predominent, ethical considerations are a significant part of the environment. Examples of such issues are the current national preoccupation with the rights of the individual, protection of privacy, freedom of information, informed consent of human subjects in research projects, disclosure and publication of research results, etc. Additionally, the social and economic costs of crime, the fear of crime (particularly in urban areas) and the concern about the degree of justice in the criminal justice system -- all impact the R/D&I environment in criminal justice. The uncertainty (about how to handle criminal justice problems and the social unrest of the 1960s) has been a primary reason for the substantial increase in criminal justice R/D&I during the 1970s.

The above often result in pressure on the R/D&I system to produce immediate results in reducing crime -- pressures that are unrealistic in the light of the lead time involved in this activity, if it is to be well done. This pressure has resulted in LEAA funding programs which have not been adequately tested, and often neglecting the collection of process information which could be useful in an evaluation designed to determine how to improve the program. The public's fear of crime has an even more direct effect on the R/D&I system by limiting the type of innovation which may be attempted. Heated protests against community corrections programs from nearby neighbors and store owners result in the kind of political pressure which can close down these innovative programs. Fear of negative public reaction to even a low percentage of failures often results in the assignment of only low risk offenders to such programs as work release, thus virtually invalidating any evaluation. Bail programs come under pressure when persons waiting trial commit further crimes.

These problems are exacerbated when what are sometimes extreme judgment errors are made; e.g.: recommending release of certain major offenders on their own recognizance. In addition, the ever present tension between individual freedom and the need for social control leads to conflicting pressures affecting innovation in the sector (e.g.: access to arrest data).

Sources of pressures affecting the criminal justice R/D&I system include congress, universities, pressure groups and law enforcement professional associations. Some members of Congress seem to be against criminal justice research of any type. On the other hand, universities and discipline associations such as the American Psychological Association press for increased commitment to research and improved project selection and design.

The consequences of the above pressures have included the creation of the NILECJ (National Institute of Law Enforcement and Criminal Justice) in the enabling legislation for LEAA (Law Enfocement Assistance Administration). This has resulted in the funding of some research and the use of funds for assistance to action programs.

3. Economic Factors

Funding agencies such as NILECJ greatly influence the types of projects and the individual investigators that are supported. Conscious policies can create major shifts in the overall nature of R/D&I. Political priorities of elected officials in turn influence the policies of funding agencies. The shift from the funding of routine hardware to that of innovative programs in criminal justice (including the development of innovative hardware) is a prime example of this process. There is currently a more supportive economic environment for criminal justice R/D&I. Federal support has increased from .17% in 1969 to .5% in 1974. Support from the private sector has also increased (private industry and more notably such foundations as Ford, Guggenheim, and Russell Sage).

As economic support has increased, the technological environment has also advanced, making the shortcomings of the R/D&I sector less acceptable and increasing expectations regarding their ability to produce usable innovations (TFCJR&D* 1976).

4. Social/Cultural Norms

Other social/cultural norms and values of society also have an impact on what research is accepted in the criminal justice sector. The use of certain drugs (tranquilizers) and certain treatments (behavior modification) have been criticized. Some apprehension and detection techniques (such as wire-tapping) tend not to be acceptable in our culture. Certain subcultures have differing views as to what is considered criminal and what are appropriate techniques to use in enforcing the law. These norms and values provide constraints as to what research can be undertaken. They also impact the diffusion process, since some new techniques are more acceptable in one subculture than in another.

Society's general posture towards criminal justice R/D&I activities (as opposed to law enforcement per se) is probably neutral. Exceptions which might raise opposition are innovations in some techniques which may reduce individual liberty (such as wire-tapping) or increase their chances of becoming a victim (such as a community corrections program in the neighborhood).

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*TFCJR&D: Task Force in Criminal Justice Research and Development 1976.

5. Related Disciplines

The knowledge base that is potentially applicable to the criminal justice sector is vast and fairly well developed. Much of the research based knowledge in other sectors is underutilized by criminal justice agencies. Information processing systems technology is just recently being exploited by local law enforcement agencies. Organizational research implications (e.g.: matrix management) are generally not applied by criminal justice organizations. Systems analysis and operations research have been finding applications in law enforcement such as in allocation of patrol resources, patrol car scheduling, etc. The basic disciplines from which the criminal justice R/D&I system may draw its knowledge include: chemistry, biology, sonics, psychology, sociology, ballistics, communication, information sciences and organization behavior. There are many mechanisms for the transfer of knowledge, from journals (although these tend not to be very sophisticated in content) to training or calling in outside experts. Barriers to transfer of technology to users include: lack of sophistication on the part of the user, lack of funds to implement the innovation, lack of awareness of the innovation and lack of desire for change. These barriers to knowledge utilization serve to discourage the effort put into the knowledge production stage (especially by business organizations) since there is a limited market for innovations.

6. Institutions Affected by Criminal Justice R/D&I

Part of the environment for R/D&I consists of the potential users of innovations. In the criminal justice sector, the potential users go beyond criminal justice institutions to also include schools, social welfare agencies, health agencies, mental health agencies, and the R/D&I systems of other sectors. One aspect of the criminal justice R/D&I system which has a strong and direct interaction with users from the environment is prevention. Most of the innovations in prevention have direct application in actions to be taken by members of the environment such as schools, property owners, etc. Thus innovations in this area must consider what proposed actions by the members of the environment will be acceptable to those parties.

As the above indicates, the interaction between the criminal justice R/D&I system and its environment is an important consideraton in the planning of criminal justice system innovations.

II. HISTORICAL DEVELOPMENT

The criminal justice R/D&I system has been functioning since crime began. Most of the early innovations were in the area of ajudication (trial by fire) and punishment (an eye for an eye, stocks, prisons). The major sector of influence was religion. The next innovations came from within the criminal justice sector (often heavily influenced by other sectors such as mental health) as practitioners sought to improve their operations (e.g.: work release).

Prior to the mid-1960s basic research specifically for the criminal justice sector was virtually non-existent. Applied research also was very rare. Most innovations consisted of applications of the results of the R/D&I systems in other sectors and disciplines. Dissemination of innovations was limited by inadequate mechanisms and a lack of resources. What innovations did occur were mainly in the area of enforcement and were developed by federal agencies, principally the Federal Bureau of Investigation.

1. NILECJ

The major event marking the beginning of the serious development of the criminal justice R/D&I system was the creation in 1968 of NILECJ (National Institute of Law Enforcement and Criminal Justice) and its parent agency LEAA (Law Enforcement Assistance Administration) (Rettig 1976). NILECJ was created with a research mission and a dissemination role. LEAA discretionary funds provided some encouragement to local criminal justice agencies to be able to acquire the innovations of the R/D&I system.

Being housed within (and subject to the leadership of) LEAA, NILECJ has been buffeted over the past decade by LEAA's unsure (the troika form of management) and changing leadership (about one administrator or acting administrator per year since inception). NILECJ itself has had several directors in the brief period it has been in existence. Henry Ruth was the first confirmed director of NILECJ in 1969. He set up the Institute in five centers: prevention and rehabilitation, law enforcement, criminal law, the fellowship program and a dissemination and technical assistance group. Director Ruth apparently spent most of his time trying to justify the role of research to Congress and LEAA leadership. This phase can be characterized as trying to obtain a foothold for research in the LEAA. The next phase began with the directorship of Martin Danziger in 1971. This administration accepted the demand that their performance was to be measured by the reduction of crime. The implication of this decision was that research funds were diverted into direct support of an action program: Impact Cities. The focus shifted to crime-specific planning. This resulted in a reorganization of the Institute into an action oriented structure. NILECJ funded large scale grants. This strategy facilitated increased political pressure on the awarding of these large sums and thus resulted in violation of evaluation design standards which in turn reduced the extent to which such programs could add to the knowledge base (NAS 1977).

Gerald Caplan was the next director of NILECJ in 1973 and he de-emphasized crime reduction as the goal. He committed the Institute rather to a long range objective of contributing to overall reduction in crime. Caplan engaged in system building activities by encouraging the participation of a research community interested in more basic research questions. He moved towards many smaller grants and tried to forge links with the academic/research community. These actions seemed directed towards a new strategy, one of understanding the social and behavioral phenomena that underlie crime. The decentralization and eclecticism of this new approach as it was implemented seemed to lack cohesion and a research agenda. The goals of the sub-units (programs, evaluation and technology transfer) seemed to be prevailing over any total Institute purpose (NAS 1977).

2. Recent Initiative

The recent initiative under the Carter Administation (1977) includes proposals by Attorney General Bell which should strengthen the R/D&I system while perhaps potentially weakening one aspect: basic research. The Attorney General's proposal includes the integration of Research & Development activities with discretionary action programming. This integration would be around an ideal formalized process which virtually institutionalizes the R/D&I system concept (policy analysis, problem definition, selection of response strategies, testing, demonstration, program design, and marketing with evaluation built into many steps). In addition the proposal includes the provision of financial incentives to local criminal justice agencies who adopt innovations which have been produced by the R/D&I system. From another perspective, this marriage of research and action could be viewed as a reduction in emphasis on basic research. One of the prior criticisms of LEAA was that the administration exerted too much influence over the Institute. Under the new arrangement, research would be linked even more closely to action programing. Some specific provision for the pursuit of basic research (which may have no immediate action payoff) may be needed. This is the type of activity which requires governmental support, due to the high risk and limited likely payoff.

The direction of criminal justice R/D&I has been largely determined by social needs. Perhaps for this reason that there has been little agreement on the primary role of R/D&I in criminal justice -- whether R/D&I should focus primarily on problem solving or on the development of knowledge. Essentially this again raises the question of control -- should R/D&I be controlled by researchers or the operating agencies (TFCJR&D 1976).

3. Other Developments

During all these years, expansion of knowledge with respect to criminal justice has continued in other places. The FBI has had a long and growing investment in methods of investigation, etc., as have other law enforcement branches of federal government (Treasury, Secret Service, the military, etc.). Much of what has come into civilian law enforcement has been derivative (especially in the equipment area; e.g.: night vision devices) from the military. Also, the R&D activities of the electronics and communications and other industries have, in the course of their own recent development patterns, contributed to the development of criminal justice R/D&I.

In summary, while beset with problems and buffetted by change, the criminal justice R/D&I system seems to have gone through its birth pangs and would now seem to be in some type of sorting out or transitional phase. However, in spite of these efforts and despite the current apparent centralization going on, it appears that it will be a long and difficult task to develop a cohesive criminal justice R/D&I system. Perhaps its high visibility and the public control through elected representatives will keep attention focused on immediate rather than longer term ventures. For the same reasons, the emphasis of criminal justice R/D&I may continue to shift (e.g.: in only ten years the field of corrections has swung from punitive to rehabilitative and back to punitive -- each switch representing public pressure from some major constituency).

III. INSTITUTIONAL BASE

R/D&I systems are usually composed of a variety of institutions loosely linked into a network. Various levels of government, industry, academia, private research organizations and foundations are included in this network. The R/D&I system includes institutions whose primary function is research and/or development and institutions which are mission oriented (have an operating or user primary orientation) but which serve some R/D&I role.

Examples of institutions whose primary functions are in the realm of criminal justice R/D&I are the Center for Studies of Crime and Delinquency (CSDC, part of the National Institution of Mental Health of the Department of Health, Education and Welfare) and the National Institute of Law Enforcement and Criminal Justice (of the Law Enforcement Assistance Administration, in the Department of Justice). These two have been described as the "most comprehensive" in this role (Rettig, 1976). There are also such private foundations and institutions as the Vera Institute, Rand and various universities. Examples of institutions whose primary functions are operations include the law enforcement agencies (municipal, county, multi-county, state and federal), the courts (municipal, county or circuit, state and federal) and corrections (municipal, county, regional, state and federal). The user agencies which have specific R/D&I components (such as research, development or evaluation) are generally the larger state and federal agencies and the larger cities (New York, Chicago, etc.). For example, state and federal police agencies are heavily involved in coordinating data collection used by many other elements of the criminal justice R/D&I system. State corrections departments often have research units, used to deal with operational problems. The great majority of criminal justice R/D&I system work is performed by institutions with such a function as their primary purpose. These institutions generally fall into four categories: government agencies, private foundations, private research organizations, and professional organizations.

Government agencies include the previously mentioned NILECJ and CSDC, and state planning agencies (SPAs) and local and regional planning units (RPUs). Private foundations are most notably the Ford Foundations (and its arm the Police Foundation) and the Russell Sage Foundation (Rettig 1976). Private research organizations, in addition to universities, include the Vera Institute and Rand. Professional organizations include the American Correctional Assocation (ACA) and the International Association of Chiefs of Police (IACP). The vast majority of R/D&I is done by these special agencies rather than by those responsible for utilization.

1. Institutions by R/D&I Function

Need Identification may be accomplished by any member of the institutional base. LEAA, along with the SPAs, RPUs and the local Criminal Justice Coordinating Committees, has a primary responsibility for need identification. LEAA has National Criminal Justice Information System (NCJIS) which provides for the gathering and analysis of national criminal justice system statistics, from which needs may be derived.

Research is principally accomplished by the National Institute of Law Enforcement and Criminal Justice (NILECJ), the research arm of LEAA. "The R&D program of NILECJ has been explicitly applied in orientation since its inception" (Rettig 1976). NILECJ funds research agencies to carry out criminal justice research (e.g.: Rand or universities). Research is accomplished by other federal agencies e.g.: DEA and Treasury, and through grants from private foundations (e.g.: Ford Foundation). Research performed in other sectors may have major implications for law enforcement; e.g.: communications, electronic data processing, ballistics and transportation (Wilson & McLaren 1972).

Development activities are generally carried out by the same institutuions as research, although users often play a larger role in this type of activity than they do in research. Criminal justice agencies develop programs, often based on research conducted by other institutions.

Business firms may take a research idea from another sector and develop it into a product usable in the criminal justice sector.

Production is handled by the producing companies, such as Motorola for communications equipment or like Xerox in more software oriented programs (e.g.: program learning materials). There is a large variety of business organizations involved in the criminal justice R/D&I system of many different sizes and degrees of sophistication. To the extent that production has to do with packaging an innovation in the form of a new program or procedure, LEAA often has a major role.

Marketing, Diffusion and Dissemination are generally handled by the producing institution, often with an assist by LEAA. Organizations like ACA and IACP play an important dissemination role.

Acquisition is perhaps the major problem, especially in cases where the user institution (police, courts or corrections) must commit funds to current or future expenditure. LEAA is again helpful in providing funds through the block descretionary program which may be used to initiate innovations, but the problem of continuation funding looms large especially in non-equipment type grants (e.g.: programs) which contain the implication that local funding will pick up the cost in a few years when federal funds run out. Beyond the above issue is the reluctance the courts have in accepting any money from an executive branch agency, since this may upset the cnecks and balances provided by separation of powers. Most of the criminal justice system is very labor intensive and the demands on the available funds are such that an increase in expenditure of local funds for new equipment and new programs is often very problematic. Innovations may be funded by expenditures made when replacing old equipment. The differences in technical sophistication of the criminal justice system's purchasing decision-maker and the producer's marketing staff might cause difficulties in the acquisition phase.

The user institutions would by definition be involved in Implementation. Support may come from other institutions (e.g.: police departments helping each other) in cases involving the introduction of new sophisticated equipment. Technical assistance may also be necessary in the event of the implementation of a new program, such as the Release on Own Recognizance programs.

Evaluation should involve all the institutions who are part of the innovation. In practice, the principal responsibility may be on the part of LEAA which has funds for evaluation purposes and a congressional mandate to evaluate. The user would tend to do some evaluation of the innovation, but generally a very unsophisticated evaluation.

2. Clustering of R/D&I Functions

The structure of the criminal justice R/D&I system is looped rather than linear. Many institutions are involved at several points in the process. The clustering of most functions is around LEAA, which has funding, research, development, production and evaluation responsibilities, not to mention technical assistance to others. There seems to be the usual type of clustering on the part of private businesses involved in the R/D&I process, principally development, production and marketing. The users may have some relation to other R/D&I functions (e.g.: some police departments have research and development units).

3. Institutional Linkages

The institutional process of R&D in criminal justice has been described as a "loose network" due to (Rettig 1976):

1. the lack of an R&D history, creating barriers to a comprehensive network;
2. bonds between R&D users are weak -- there are few linkages within and between the sub-systems;

3. the establishment of bonds between R&D and users are not the result of research; and

4. statutes limit the roles of R&D institutions in implementation particularly in the federal government.

An exception to this may be NIMH's Center for Studies of Crime and Delinquency which is a "total Center". This institution has among its responsibilities the development of a coherent R&D program, including implementation. Nonetheless, the linkages within the subsystems clearly are weak or nonexistent. The associations within functions on the part of the sector operating elements provides some exception to the above statement. Members of professional associations exchange ideas and evaluations regarding innovations. At most levels within the criminal justice R/D&I system there is more of a competitive than a cooperative relationship (university research versus private research) due to competition for limited funds. This problem was recognized in an Illinois Regional Planning Unit which identified the need for better system coordination as a major priority (Greater Egypt Regional Planning and Development Commission 1977)

IV. GOALS, POLICIES AND STRATEGIES

1. System Approach

One may profitably review the section on historical development for a discussion of the goals of the NILECJ from its inception up to current plans. Regarding the criminal justice sector itself, the bringing together of representatives of the three major sub-sectors (police, courts and corrections) on criminal justice planning committees has accentuated the differences in goals, policies and strategies. Even the overall system goal of reducing or at least containing crime is not agreed upon. Beyond that, there is almost no agreement among the sub-sectors or even within them as to what is appropriate policy and strategy for the system. The opportunity for innovation (at least for successful innovation) is severely limited by the lack of goal consensus on the part of crucial sub-sector institutions. Programs which cross sector lines are very difficult to implement, and even within-sector programs may be undermined by other sub-sector institutions (e.g.: police arresting work-release residents on suspicion, causing them to lose their jobs). The hope of reaching goal consensus in a situation of function accountibility is very slight. System accountibility might reduce the current goal conflict.

2. Functions

LEAA and NILECJ have institutionalized these functional differences by setting up separate program areas for courts, police and corrections. The fragmented goal structure of this lead agency therefore mirrors the fragmented and conflicting goal structure of the sector it is leading. More specifically, R/D&I activities in the criminal justice sector indicate that attempts are being made to develop guidelines that will be useful for setting up goals/policies/strategies that are less vulnerable to the passage of specific new legislation. Also, attempts are ensuing to draw together many issues on the conduct and management of R/D&I activities that have been frequently raised in the past. The concern here is to serve as an important resource for criminal justice policy makers and to create guidelines for the conduct of R/D&I in this sector which will serve well during the next five to ten years (IFCJR&D 1976). It is just beginning to be recognized, for example, that an appropriate balance must be struck between the allocation of funds to basic and applied research and to the achievement of short, intermediate and long range goals.

3. New Strategies

As discussed under the section on historical development, NILECJ has moved from a goal of encouraging basic research; to one of reducing crime; to improving the criminal justice system. Strategies have shifted from many small grants to universities; to a few large grants to operating agencies; to the current small grants to many institutions. Policy has shifted from being the cutting edge of innovation; to providing support for action programming; to the current thinking of NILECJ driving the innovation process.

Changes in LEAA administrators, changes in NILECJ directorship, changes in public demands and changes in Congress's attitude towards research -- all continue to buffet this key agency in the criminal justice R/D&I system.

V. ADMINISTRATIVE PROCESSES

1. Administrative Processes by R/D&I Function

Administrative processes in the criminal justice R/D system are best understood by emphasizing the difference in the organizations found at various points in the system.

At the research and at the development stages, the system includes organizations from both the private and public sectors, including private profit organizations, university research centers, federal agencies, and professional associations. Few general statements could adequately characterize the administrative processes of these diverse organizations. The level of sophistication of the processes of some of these organizations is high and is representative of the type of organization (i.e. federal agency, private profit organizations, etc.) rather than a reflection of the criminal justice sector. The level of sophistication drops off markedly in other organizations -- e.g.: smaller business firms, universities.

At the production, marketing and distribution stages the system more prominently includes private organizations and these organizations reflect the diversity of sophistication of administrative processes one would expect to find in a wide assortment of technologies and organizations. The level of sophistication is generally (though with some variation) fairly high and is not so much a function of participation in the criminal justice R/D&I system but rather of other organizational characteristics (size, technology, major product line, etc.).

The functions such as acquisition, implementation, utilization and evaluation are primarily associated with the user organizations (e.g.: police departments). There is wide variation in user agencies in terms of size and level of sophistication, thus resulting in a similar variation in administrative processes.

The administrative processes of organizations in the R&D stages of the R/D&I system are more sophisticated when compared to the user organizations. However, any general statement must be amended with a caution to distinguish, within any general category, between organizations of different sizes, with different product lines, etc.

2. Administrative Activities in the Criminal Justice System

Policy makers in criminal justice R/D&I are generally governmenc employees at the federal,state and local unit of government level, and in that capacity they decide what kinds of research should be supported (TFCJR&D 1976).

R/D&I activities in criminal justice are conducted by university groups, non-profit organizations, and government operations. Key policy decisions regarding these activities are often not made by practitioner agencies but rather by the agencies that sponsor or fund R/D&I projects. Because criminal justice R/D&I has become relatively centralized, with a few federal agencies supporting the bulk of research (LEAA, HEW), the federal government exercises most of the decision-making power over the scope and direction of R/D&I, particularly when it is not in response to a specific local problem (TFCJR&D 1976).

Some coordination does exist within and among criminal justice R/D&I agencies. Notable examples are coordination by the SPAs of the regional planning units, and coordination of the state planning agencies by LEAA. Coordination at other levels and in other institutions can be enhanced by cross-institutional boards serving as an instrument to coordinate overall policies that affect criminal justice R/D&I agencies in general (TFCJR&D 1976).

3. Administrative Procedural Considerations

Four important managerial procedural considerations have been described for the "project" process (TFCJR&D 1976):

1. Preproposal interaction between R/D&I agency staff and prospective R/D&I performers;
2. A formal process by which research proposals are reviewed and grant or contract award decisions are made;
3. The monitoring of funded proposals; and
4. Evaluation of results of completed projects.

Although these processes are important, and being performed within the LEAA framework, the ultimate indicator of the administrative process of R/D&I in a problem-focused system such as criminal justice is whether or not innovations are implemented and have an impact on the system.

VI. PERSONNEL BASE

The Personnel Base is a critical aspect of any organization or system. This is particularly true in an R/D&I system which so heavily involves the human component -- as does the criminal justice R/D&I system.

1. R/D&I Personnel

Two types of personnel are important in criminal justice as in any kind of R/D&I activity -- managers and investigators. The qualifications of these personnel directly affect the quality, relevance and utility of the R/D&I system.

Despite the difficulty in establishing guidelines for the appropriate amount of training and experience for the professional staff, competent R/D&I management is an essential objective for the R/D&I agency funding especially in an applied research area such as criminal justice.

The following is a possible description of the personnel base of a funding agency as proposed in a recent report on criminal justice R/D&I. "Such an agency's staff should contain at least two or three leading members who have a significant research status and at least one individual with strong administrative and political skills. It is not necessary for the agency head to possess all of these skills -- administrative and political skills would be more important for this individual than research skills. However, as a total staff, all of these skills should be well represented " (TFCJR&D 1976). It is interesting to note the recognition of the required blend of skills.

An example of an agency with highly trained personnel is the NIMH's Center for Studies of Crime and Delinquency. Their staff of seven includes two psychologists (one clinical), one political scientest, one social psychologist, one criminologist, and one social worker. The staff is strongly oriented towards the research performer community and is considered one of the more competent R/D&I institutions in the criminal justice sector (Rettig 1976). Their responsibilities include making presentations at meetings, writing articles for practitioner journals, dissemination of information regarding available grants, working with prospective grantees on proposals and concept papers, etc.

There are few available prescriptive criteria for determining desirable professional staffing patterns. A suggested (TFCJR&D 1976) optimal staffing pattern is one based on an independent assessment that covers the relationship between the aquisition of high quality R/D&I personnel and the recruitment, retention and work load policies. Such an assessment can be supported by the R/D&I funding agency itself or by agencies of private organizations concerned with personnel management.

Some problems have been identified by the TFCJR&D report regarding criminal justice personnel for R/D&I. Due to the recent rapid growth of available funds for R/D&I in the criminal justice sector, it is difficult to achieve adequate levels of competence in research investigators. The availability of funds has resulted in a sharp increase in the number and types of researchers who do criminal justice R/D&I activities. Although formerly consisting of a small research community, currently R/D&I personnel come from widely scattered backgrounds including accounting, law, operations research, economics, political science, engineering, architecture, etc. A learning period is required before they can be effective in the criminal justice sector.

2. User Personnel

Criminal justice agencies (user organizations) are labor intensive. Since user or potential adopter attitudes toward innovations are critical to the rate of innovation adoption, the criminal justice R/D&I system faces a fomidable obstacle in the personnel resources of its user organization. Some changes are being attempted by up-grading the selection criteria (e.g.: college education).

Some distinctions regarding personnel must be made between the various functions within a criminal justice agency. To the extent that various functions (e.g.: in a police operation: patrol, investigation, detection, etc.) become specialized, the personnel resources must also become more specialized. This specialization can lead to greater rates of adoption of some innovations. For example, diffusion of communications innovations can be greatly assisted by the existence of communication specialists in the police departments. Logically, such specialization leads to greater awareness of available innovations, greater support for their utility and, in general, represents a greater source of "product champions" within the user organization.

This specialization of personnel also can lead to efforts for some specialization to aspire to a professional status. The organizing of associations of specialties such as communication officers, or forensic laboratory managers, is evidence of such a professional direction. This movement could encourage innovation through providing a vehicle for dissemination.

LEAA is helping criminal justice personnel to increase their sophistication by providing training. LEAA also funds universities to provide criminal justice programs through LEEP (Law Enforcement Education Program). Northwestern University's

Traffic Institute program includes a course in management of change which directly deals with innovation processes.

As professions from other disciplines interact with criminal justice personnel, both may become more effective participants in the criminal justice R/D&I system.

VII. FUNDING

1. Sources

Expenditures on the criminal justice system during 1975 at all levels of government (state, local and federal) are estimated at $16 billion in 1975. The total expenditures for the R/D&I system are estimated at less than ½% (Rettig 1976). Regarding the total criminal justice sector, the sources of funding are appropriations of governmental bodies, such as city councils, state legislatures, and Congress. Like all other governmental activities, the level of funding is rarely adequate to meet the needs, but it has been rising steadily over time. Between 1969 and 1976 there was an over 800% increase in criminal justice R/D&I funding, from $13,443,000 in 1969 to an estimated $110,223,000 in 1976. This increase is principally due to increases in the LEAA budget as shown in Figure 1

Agency	FY1969	FY1976 (est.)
Federal Judiciary	67	3,700
Dept. of Defense	0	20
HEW	5,773	4,267
Dept. of Justice	6,413	98,154
Dept. of Transportation	519	3,231
Treasury	0	840
Others	711	-
Total	13,443	110,223

FIGURE 1

Crime Research and Statistics -- U.S. Government Outlay by Agency*
($ in thousands)

* TFCJR&D (1976)

Various private foundations support research in this sector (Ford Foundation, Guggenhein Foundation and Russell Sage). In some cases, funding for research is different to separate from action funding. Law enforcement surfaced as a major political issue in the 1960s and this led to the passage of the Omnibus Crime Control and Safe Streets act of 1968 which provided the funding for criminal justice system activities. The committment to this issue (as reflected by the funding and the amount of controversy surrounding the hearings) after a period of steady growth, has now leveled off -- LEAA providing approximately $800 million annually. This reflects a small committment relative to the total national criminal justice budget as follows:

Year	Percentage*
1967	0.16
1970	0.15
1971	0.22
1972	0.24
1973	0.35
1974 (est.)	0.46
1975 (est.)	0.47

FIGURE 2

*Federal R&D as a Percentage of Total National Criminal Justice Expenditures (TFCJR&D, 1976)

This compares to the following percentages in other areas (Radnor, Spivak and Hofler 1977).

Education.	0.3%
Agriculture	1.1%
Health	4.6%
Industry	3.4 to 5.0%

FIGURE 3

The two largest government criminal justice R/D&I institutions, NILECJ and the Center for Studies of Crime and Delinquency (CSC&D) have the following funding (Rettig 1976):

Year	Funds: Appropriated	Expended
69	3,000	290
70	7,500	2,626
71	7,500	6,081
72	21,000	9,558
73	31,600	19,900
74	40,000	32,619
75	42,500	39,201

FIGURE 4

NILECJ:

Funds appropriated and expended FY 1969 to 1975
($ in thousands)

The CSC&D has an annual operating budget of approximately $4 million. These funds are expended in the approximate ratio of 60% research and 40% training.

In the private sector, the major funder is the Ford Foundation, expending $70 million in grants between 1951 and 1970. Additionally, Ford endowed the Police Foundation with $30 million (Rettig 1976).

Although no detailed analysis has been performed, the research task force of NIMH reported that research on social problems, including crime and delinquency, is underfunded (Research Task Force 1975). In spite of the fact that funding has increased significantly over the past decade, law enforcement and criminal justice are not especially R&D intensive as a policy area.

As indicated, the federal government is the major source of R/D&I funds in criminal justice. Much of this money is spent by non-federal government agencies. Slightly less than 28% of the total Federal R&D budget is spent in government labs (Federal Funds 1974).

Most of the primary sources of funds are in the form of appropriations (e.g.: Congress appropriates to LEAA). The secondary sources tend to be grants usually on a sole source basis. There is some competitive bidding for grants and probably more for contracts (especially on a RFP basis) but the decision basis is usually competence or considerations other than low bidder.

LEAA funds almost exclusively solicited proposals. There are 3 types of solicited proposals:

1) competitively solicited (open);

2) competitively solicited (limited); and

3) individually solicited (sole source).

Most funding is for limited competitively solicited proposals. Furthermore, LEAA must make a decision on, or suspend, a proposal within 90 days of receipt or the proposal is automatically funded, and this arbitrary timetable definitely affects the quality of proposals (Rettig 1976).

2. Impact

Availability of funding becomes an even more crucial issue at the user level, when state and local governments are asked to use local tax revenue to acquire and implement innovations or to continue federally funded programs. These funding problems may result in limited success of the "marketing" effort. The state and local response to the "seed" money approach of the block grant program has been in many cases to use the money for one shot expenses (equipment, training, construction). This minimizes the impact of the program on future local tax revenues (as opposed to a new program which would require new staff and commitment of continuing funds).

Many criminal justice system agencies actively seek LEAA funds even though grants represent a small percentage of their total budget since operating budgets provide little resources available to fund innovations.

The private sector (industry) evidently does not see enough of a return on investment to do much direct research on criminal justice system innovations (Radnor 1975). The basic research is often federally funded or most commonly done for some other sector (e.g.: communications technology for the space program). The Equipment Systems Improvement Program (ESIP) program of NILECJ was an example of trying to involve the private sector in research activities in the innovation of new equipment for law enforcement, through the provision of federal funds (Radnor 1975). In sum the most critical issue from the view of this analysis of the area of funding is the funding for the acquisition, implementation, utilization and evaluation of innovations. Funds must be obtained from the state and local revenue base and criminal justice agencies often lose out in the competition with agencies serving other needs.

VIII. INFORMATION FLOW

1. Current Situation

Information flow in the criminal justice R/D&I system generally coincides with the network of institutions in the system. There tends to be lateral transfer of information between units with similar functions, particularly at the user and research levels. User organizations seem to communicate freely with each other through both formal and informal networks. Research organizations, particularly at the federal or national level, seem also to interact. The differences in levels of sophistication at the two ends of the system tends to impede the exchange of information between levels.

Most communication between criminal justice user organizations are informal, with respect to transferring information about innovations (Radnor 1975). There is considerable informal contact, particularly at local, state and regional meetings and conventions. In a few instances, these informal contacts have evolved into institutionalized systems to communicate and cooperate in efforts to introduce innovations into the organization.

The information transfer takes place, for example, not only between chiefs of police at conferences sponsored by the International Association of Chiefs of Police (IACP) and by local and state associations, but also at the more specialized/professional gatherings, such as the Association of

Public Safety Communication Officers (APSCO). Such conferences appear to be vital in the transfer of innovation information. Professional organizations serve similar information transfer functions for the courts and corrections.

Periodicals and magazines, such as Police Chief and Probation, are also important means of information transfer. Such periodicals not only make users aware of available innovations but also provide a degree of evaluation of some innovations.

Of particular importance in the transfer of technical information for police is the IACP publication. It publishes periodically (monthly) detailed information sheets regarding specific law enforcement equipment and supplies. Such information includes description, performance specifications, and manufacturers. The same organization provides, for a fee, an evaluation service for any listed products (but not, it should be noted, at a rigorous and sophisticated level).

The National Institute for Law Enforcement and Criminal Justice (NILECJ) provides an information diffusion service (Rettig 1976), primarily for information about activities sponsored by the Institute. One category of information is the standards for criminal justice equipment developed by the National Bureau of Standards. However, Radnor (1975) found little use of these standards by either users or producers. The users found them too sophisticated technically: the large producers felt they neither needed nor wanted government imposed standards.

2. Problems

One major problem in information flow of the criminal justice R/D&I system is derived from a fundamental problem of the criminal justice sector; the lack of a cohesive network with agreed upon goals and priorities. The criminal justice system does not function as an integrated structure, striving to achieve the same overall goals and with some agreement on appropriate strategy. Rather it is a loosely linked structure with major disagreements on strategy and with strong political pressures on agencies to optimize their individual goals, resulting in subgoal optimization for the system. Thus information flow within the criminal justice system, but across function lines, is restricted by disagreements and competitiveness.

The freedom of information/right-to-privacy issues affect the flow of information from practitioners to researchers, particulary the flow of raw data and its verification. This results in the duplicate collection of the same data by various R/D&I institutions in some situations, or sometimes the inability to collect needed data at all in others.

A third problem (as noted earlier) is that differences in levels of sophistication between the knowledge production and knowledge utilization parts of the criminal justice R/D&I system tend to impede exchange of information between them.

IX. INNOVATIONS

1. Two Alternative Flows

In an applied system, such as criminal justice, innovations frequently may not stem from a laboratory or from university research. Figure 5 below describes two alternative innovation flows as described by the Task Force on Criminal Justice Research and Development (TFCJR&D, 1976).

As the diagram shows, innovations may be "practice-to-practice" or "knowledge-to-practice". Practice-to-practice innovations typically result from employee suggestions, ideas from supervisors or other initiatives within an operating agency (user). Knowledge-to-practice innovations result from the traditional R/D&I process. Additionally, there appears to be no known comparison of the relative frequency or importance of these two approaches to criminal justice innovation. This is an area clearly requiring further empirical research.

2. Successful Innovations

Although there have been innovations, dramatic improvements have not occurred in spite of substantial R/D&I efforts in criminal justice. A few examples of successful innovations include the identification of a processing bottleneck of persons arrested for felonies through a court simulation system, two-way radios for communications,* report recording devices, lights and sirens, polygraph equipment, voice prints, riot control equipment, architectural innovations for jails, EDP equipment for offender based tracking systems, release on own recognizance programs, community-based correctional programs, behavior modification programs, police patrol allocations, training and educational programs, forensics, etc. (Twentieth Century Fund Task Force on the Law Enforcement Assistance Administration 1976).

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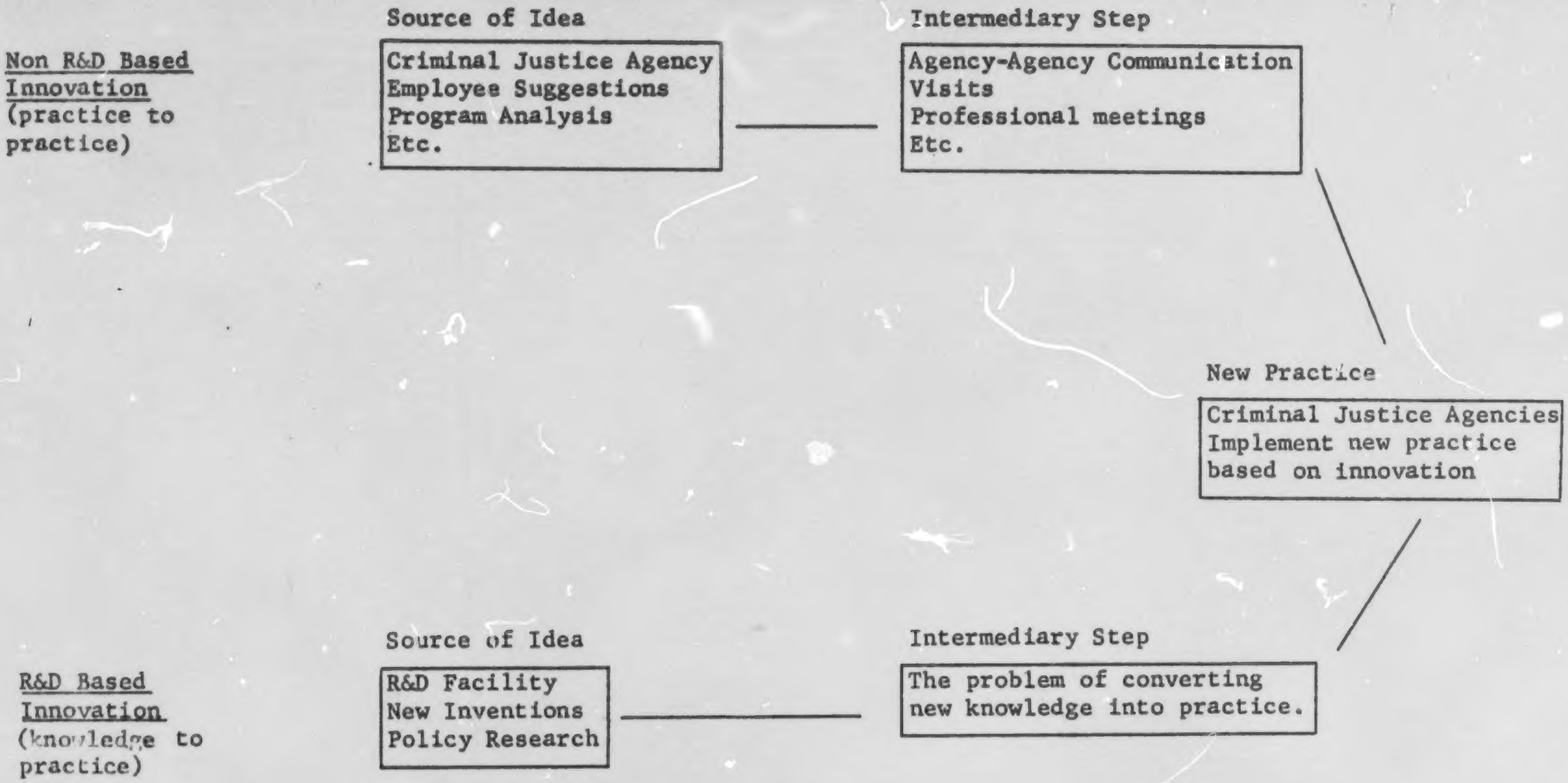
*Although, according to Radnor (1975) they would not include the NILECJ supported program (see comments on this in Feature XIV).


Non R&D Based Innovation (practice to practice)
Source of Idea
Criminal Justice Agency
Employee Suggestions
Program Analysis
Etc.
Intermediary Step
Agency-Agency Communication
Visits
Professional meetings
Etc.
New Practice
Criminal Justice Agencies Implement new practice based on innovation
R&D Based Innovation (knowledge to practice)
Source of Idea
R&D Facility
New Inventions
Policy Research
Intermediary Step
The problem of converting new knowledge into practice.

R&D vs. NON-R&D BASED INNOVATIONS

FIGURE 5

3. Problems

In criminal justice the focus on specific innovations to solve individual agency problems has been the major approach to improving practice. However, as pointed out in the section on institutional base, the criminal justice network is fragmented and lacks a true system interconnecting its parts. Although this focus is on the specific mechanisms to facilitate the transformation of knowledge to practice, it reduces the probability of any single innovation being developed for the whole system, or for innovations being disseminated for use throughout the system. The result is minimal "dramatic improvements" within the system.

Criminal justice R/D&I faces an additional major problem. Innovations are generally developed by groups that are external to user institutions. This requires dissemination and results in a tenuous link between knowledge and practice. It also leads to implementation by the user agency only so long as external funds for special "innovative" projects exist (Yin et al. 1976).

X. NEED IDENTIFICATION

1. Traditional Sources

Decisions of the Supreme Court can affect needs, such as in the handling of criminal arrests or the conditions in which prisoners are housed. Congressional legislation and changes in Administration often result in new views as to what is needed and changes in previously established priorities among already existing needs. For example, Congress has deemed that community anti-crime programs (prevention) are needed. Prior administrations have focused on crime in the street (apprehension), while one current focus is neighborhood justice centers (diversion).

In the criminal justice sector, need identification is somewhat less than systematic. Rather, needs are identified by Congress, legislatures, the media, producers with new products to market, the public and institutions within the criminal justice sector. Much of criminal justice need identification is done by producers, who have new products developed for other sectors (e.g.: communications technology) and want to identify needs in criminal justice in order to broaden their market. One might say the issue of police response time was raised to awareness by the availability or improved computer software for patrol allocation plus the availability of improved communication equipment. A heightened awareness of individual or prisoner rights can lead to needs being identified which always existed, but were not salient.

2. New Sources

LEAA has the potential for the systematic assessment of needs, in its National Criminal Justice Information System (NCJIS). LEAA has recently instituted a mechanism for bringing identified needs to the attention of the decision makers: a formal decision memo. This memo specifies the need and proposes some general approach to dealing with the need.

The LEAA legislation (Part B) establishes a network for the identification of needs by providing planning funds. This network includes local criminal justice planning, involving sector institutions, government and public representation. The needs identified are in the plans of the SPAs for each state. Of course, these local and state plans are at least as subject to political and special interest pressures as the federal plans.

The research arm of LEAA, NILECJ, also identifies needs through surveys and analyzing criminal justice data. The NILECJ responds to requests from the action program offices of the LEAA organization to research needs that the program people have identified; responds to requests from the administration to pursue needs that the administration has identified; responds by funding a university to look into a need which the university has identified; and responds to needs identified by Congress in the enabling legislation.

When the criminal justice system develops a more systematic approach to need identification, lEAA in general and NILECJ in particular will be in a stronger position to buffer the agency against the more random identification of needs by various actors outside of the system.

XI. GENERATION/RESEARCH

1. Basic Research

Basic research in terms of search to determine what knowledge already exists, creation of new knowledge and synthesizing existing knowledge is very limited in the criminal justice sector. This is because most of the effort is on applied research (problem-focused rather than "pursuing" knowledge). It is the basic research of other disciplines such as sociology, psychology and operations research that is utilized in the criminal justice sector; i.e., it is a derivative field. There is little direct transfer of pure knowledge from the other sectors to the criminal justice sector; rather developed products and processes are adapted in production or directly move into the marketing stage (e.g.: communications equipment). Criminal justice basic research is done in some areas (e.g.: causes of crime, voice prints and forensics). This research is carried out by universities, private industry and government.

2. Applied Research

Applied research (disciplined inquiry seeking to produce knowledge applicable to the solution of a specified problem, and either driven by an identified need or by searching for the application of the results of some basic research) is more prevelant than basic research in the criminal justice sector. Again, the applied research of other sectors is more important to the criminal justice R/D&I system (for example knowledge developed through applied research on communications, various operations research activities, etc.). Institutions involved in applied research are more numerous than those involved in basic research, and the intensity of the involvement is greater.

3. Issues

Some of the basic issues and considerations for criminal justice R/D&I include (TFCJR&D 1976):

1. There is a need to better describe the role of the researcher -- his/her autonomy (or lack of it); balance between the researcher's creativity and agency goals and priorities.

2. As the majority of criminal justice research involves human participants, they must be protected. The current sensitivity to individual rights of privacy and confidentiality, statutes and administrative regulations regarding informed consent, protection of sensitive data, etc. all impact the criminal justice researcher and his/her ability to perform effectively and efficiently.

3. The selection of topics for R/D&I is difficult considering the lack of system continuity (see Goals, Policies, Strategies) with their lack of agreement.

4. The choice of research methods, which should be determined in relation to the type of R/D&I activity and its overall purpose, is difficult due to the above issues.

5. Although there has been an increase in the amount of R/D&I effort in criminal justice over the past decade, there is still considerable need at the most basic level -- development of compatable definitions, developing research hypotheses,

designing research studies, and developing sound relationships between the research team and the user agencies (TFCJR&D 1976).

6. There has been a major shift in criminal justice research directions. Interest in individual personality theories has decreased while interest in sociological theories has increased. This may be demonstrated by the recent interest in the pattern of crime through the numerous victimization studies in the 1970s.

4. DATA

As alluded to in item 2) above, there are significant problems regarding data resources (obtaining data, and the form in which it is obtained). For example, in Illinois, obtaining data on juveniles frequently requires a court order. Additional difficulties have been identified in the area of data problems (Bisco, Ralph L., 1970). Much of the data that has been collected is unused. Geographical dispersion of the data sources results in not knowing what data exists, difficulty in determining validity, duplication and tremendous expense. Bisco states that it is 15,000 times more expensive to collect data than to copy pre-existing data. Both the issues and problems are relevant to both basic and applied research in the criminal justice sector.

5. Linkages

The LEAA performs and funds applied research trhough the NILECJ. This unit funds universities, private research organizations and other grantees to work on applied research. User agencies with new approaches to identified problems may be funded to try out an innovation, and as long as it involves disciplined inquiry it would come under the category of applied research. LEAA provides a linkage between this function and other aspects of the R/D&I system. The agency may fund users to be able to acquire the innovation, thus encouraging further development, by a producer. Also LEAA may fund a producer to develop the results of applied research. These linkages are imperfect, but the agency is presently working on a system to strengthen them. This system, Action Program Development Process, specifically links action programs to research.*

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*The process is currently being implemented with the assistance of CISST staff.

XII. DEVELOPMENT

1. Criminal Justice Development

Regarding the criminal justice R/D&I system, development work is generally accomplished by other sectors (particularly when related to equipment), with only minor adaptation necessary; or by practitioners or users, testing out their ideas (particularly in the development of programs). Some equipment is specifically developed for this sector (such as "Mars Bars", light flashing/siren systems for patrol cars). Producers do much development work in the equipment area, while users often fill that role in the area of programs. Innovations of a process type are often developed by an operations research organization (e.g.: patrol car scheduling processes). The funding situation of the users often discourages the investment of private money in developing needed products. Thus the LEAA role is vital in this development function.

2. LEAA Role

The LEAA has tried to encourage private investment in development by creating the hope that money would be made available to local agencies (through block or discretionary funds) for the acquisition of the innovation. Further, LEAA encourages development by providing market research data through efforts at the assessment of needs of the criminal justice sector.

Finally LEAA engages in (and funds others to do) development work. One major problem is the weakness of the linkages between development and users. LEAA is working on improving these linkages and is engaged in system building at least within its own somewhat fragmented agency. The activities engaged in under the rubric of demonstration usually include development efforts, while the testing activity often includes dissemination elements. The agency is trying to move the criminal justice sector closer to a clearer distinction between activities such as testing and demonstration.

Linkages between developers and users are being forged with instruction manuals and support services, such as training. Especially in the case of new programs or processes, LEAA serves a key linking role by the funding of, or participating in production activities.

XIII. PRODUCTION

1. Critical Linkage

The production function is a critical R/D&I function within the overall flow of innovation from knowledge production to knowledge utilization. In the case of a physical product (as opposed to a program or process) the decision to produce something especially for the law enforcement sector will be based on many factors. One primary factor will be the anticipated market for the innovation. Derived from that and other considerations may be the anticipated margin or gross profit. Further consideration will be given to the ease of production in the existing facilities utilizing existing equipment. However, often the product is already being produced for some other sector and therefore production is not really an issue for the criminal justice R/D&I system.

In the case of programs or processes, production becomes an issue of preparing instruction manuals and providing support in the knowledge utilization functions (support such as help in installation, implementation assistance, plus training and perhaps trouble shooting). Thus there is a strong interaction between how well the production is accomplished and the amount of support services required down the road, not to mention the marketability of the program or process.

It is probably key,in the case of a product, to obtain answers to the marketability and profitability questions prior to the investment of major research and development funds; and to ascertain the likelihood of finding a producer.

2. Recent Initiatives

LEAA (through NILECJ) undertook a program in the early 1970s to advance the equipment being used in the criminal justice sector. The program was called ESIP (Equipment Systems Improvement Program). The program had many problems associated with it, including a number related to production. At least in some elements of the criminal justice sector, there was seemingly so little hope that a profitable market could be found (in terms of local funding availability and other problems) that producers could not see a price/volume combination that would justify investment in volume production, and hence were generally not attracted to the new products addressed in the ESIP activity (Radnor 1975). To some extent, a very broad demonstration program on the part of LEAA (e.g.: to improve prison overcrowding) could possibly function as insuring enough of a market to entice producers to invest in an innovation.

A notable example of the difficulty in production for the criminal justice sector can be found in the communcations area. LEAA sponsored the development of a lighter, less expensive and more efficient portable radio than current equipment. However, upon the completion of the development, it was unable to identify a producer willing to assume production responsibility (apparently due to the likelihood of small returns). Consequently that particular portable radio has never reached the users for which it was intended (Radnor 1975).

To some extent LEAA produces "packages" for dissemination (see the section on dissemination). Production takes place in two forms -- "exemplary programs" and "prescriptive packages" which are developed for dissemination as many prospective users as possible. The production is sometimes accomplished by outside contractors as a result of direct funding by NILECJ (Rettig 1976).

3. Production Sources

The production function in the criminal justice sector is performed by a wide variety of organizations. Equipment is produced by private, for-profit firms which range from very small to very large in size and which may focus on criminal justice as their primary market or (more likely) may consider criminal justice to be a secondary market (Radnor 1975). Production of "packages" for dissemination ("exemplary practices" and "prescriptive packages")* is provided by NILECJ through its funding of outside contractors (Rettig 1976).

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*See section XIV on Dissemination.

XIV. MARKETING/DISTRIBUTION/DISSEMINATION/DIFFUSION

1. Marketing

Of the above categories, marketing is most applicable to the equipment aspects of the criminal justice sector, while dissemination is appropriate for the procedure and process innovation. This major linking function between knowledge production and knowledge utilization is an important consideration during decision-making activities of the prior stages. The production decision should not (but often is - Radnor 1975) be made without considering marketing opportunities and strategies. To the extent that the criminal justice R/D&I system is driven by need identification at the user level, and that the acquisition issues have been considered, then the marketing decisions would be made early in the process. If the user has the funds to acquire the innovation and recognizes that it is in response to needs that he has participated in identifying, a receptive market should be found, though these conditions seem frequently to be absent. To the extent that LEAA provides seed money funds for the adoption of innovation, dissemination may also be facilitated.

2. Problems

Marketing and dissemination in the criminal justice sector are faced with the problems of a fragmented and diverse grouping of organizations which function at all levels of government, which vary extremely in size and sophistication, and which are geographically dispersed.

A notable example of the difficulty for the criminal justice sector can be found in the communications area. As mentioned before, NILECJ sponsored the development of a portable radio intended to be lighter, less expensive and more efficient than current equipment. However, upon the completion of a relatively successful contracted out development program, it was unable to identify a producer willing to assume marketing production and field service (a very costly factor) responsibility due to the likelihood of small returns. Consequently the equipment has never reached the users for which is was intended (Radnor 1975).

The problems of communicating information about a new product to a large urban police department are vastly different from dealing with a small rural enforcement activity. On another dimension, different orientations are present across various parts of the criminal justice system (corrections, courts and police). Disseminating knowledge about an innovative program which requires the cooperation of all parts of the sector is thus difficult (such system-wide innovations are very rare). LEAA has developed specific dissemination activities within NILECJ such as the Office of Technology Transfer (Rettig 1976). These activities include arranging seminars, visits to sites of demonstration programs, demonstration programs themselves, and the provision of data about the programs (NILECJ April 1976).

This step is interactive with the amount of support available to the adopting agency. If project selection decisions are informed by user need identification, then selection of location for demonstration programs would include consideration of the potential marketing benefits of strategic locations of demonstration projects.

Producers of equipment (e.g.: for police) face a two phase market, wherein they first have to sell the larger more sophisticated agencies (large metropolitan departments and/or state police units) and then await the word to reach the many dispersed small units through their contact with people in the larger units. Marketing may include appearing at professional conferences to show equipment or describe a new program.

3. Other Dissemination Activities

Another dissemination activity of LEAA is the National Criminal Justice Reference Service, the national and international clearinghouse for reports, studies, etc. This clearinghouse sends abstracts of documents or completed documents to over 30,000 subscribers who have indicated their special areas of interest in the criminal justice system. Included in this dissemination are prescriptive packages and exemplary programs. Additionally NCJRS will respond to specific inquiries with a computer printout of all abstracts in that area. Information disseminated through this service includes innovative programs, processes, new equipment (and their evaluation when completed), films, announcements of training programs and conferences, etc. (Rettig 1976).

LEAA encourages the adoption of innovations on the merits of the program without any financial incentive through its review of the plans of state planning agencies, through its discretionary funding programs, and through direct marketing or innovations to the criminal justice sector. This is a new emphasis for this agency, one which has implications for the other operations of the agency. If programs are to be marketed or disseminated based on merit rather than as a method of dispersing federal funds, then the evaluation process throughout the R/D&I system would be affected. To encourage local agencies to try to obtain funds from local government for innovations would require facts which clearly indicate the efficacy of the innovation. The specification of the marketing activity as a specific step in the LEAA process of program development may thus have a major impact on evaluation throughout that agency.

XV. ACQUISITION

Acquisiton is the beginning of the knowledge utilization part of the innovation process. This function represents the activities which the user goes through in order to obtain the innovation. Acquisition steps and procedures have a major interaction with the previous function, marketing. Dissemination strategies take into account the structure and capacities of the acquisition function. For example, since most of the market is relatively unsophisticated in the acquisition function and usually relies on the larger criminal justice agencies which serve as leaders in innovation, then the acquisition activities of these leaders become critical for the entire sector.

1. Problems

Acquisition involves: awarenenss, search, bidding, testing, evaluation and finally purchasing. Generally criminal justice agencies lack the resources and technical skills for conducting testing and evaluation. LEAA attempted to provide standards for criminal justice equipment through ESIP (Equipment Systems Improvement Program). IACP (the International Association of Chiefs of Police) provides independent evaluation of the products. The principal impetus to acquisition is still informal communication from the leading agencies to the followers. This may come from meetings, conventions, trade journals or informal communications. One function of national (and international) training programs such as Northwestern University's Traffic Institute or the international training program of the Federal Drug Enforcement Administration is to provide an opportunity for professionals to exchange information about the latest innovations in equipment and processes.

2. Funds

A great barrier to innovation is the lack of funds with which to purchase the new equipment. Most of the budget of law enforcement agencies goes towards personnel or fixed costs such as cars for police or food for prisoners. Thus little discretion is left for new innovations. The Omnibus Crime Crontrol Act of 1968 and the agency created therein (LEAA) have opened up the opportunity for state and local criminal justice agencies to engage in acquisition of innovations (Rettig 1976). This bill did not create the sophistication necessary for an effective process of acquisition. Some sophistication was brought into the system by creating state planning agencies which were responsible for approving the expenditure of block grant funds. This agency both imposed constraints (such as requiring bids) and provided some technical assistance in acquisition processes (such as standards for communication equipment).

To some extent the influence derived from the control of the funds was used to impact the form of innovation (such as requiring communities of a certain size to join with surrounding communities in developing communication programs). The LEAA office in Washington has more control over recipients of money which is directly controlled by the agency's discretionary funds program and research program. Specific acquisition procedures may be imposed regarding bidding and standards. Acquisition activities in the program, procedure and process area are primarily driven by awareness of an existing innovation rather than awareness of a need. An exception might be a highly visible critical event which demands immediate response -- a series of killings, an assasination, airplane highjackings, etc. More typical is the situation where a lead agency (e.g.: LAPD, California prison system, Massachusetts juvenile system) develops an innovation; and the acquisition process consists of adopting the lead agency's innovation. Programs such as Work Release and the Des Moines project were promulgated in this manner.

3. Courts

A special problem exists in the court area of the criminal justice system. LEAA funds and attendant requirements were viewed as a possible violation of the separation of powers provision of the constitution, so the courts generally refused to apply for LEAA funds.

Recent legislation, amending the enabling law, specifically eliminates various constraints to the use of LEAA funds by the courts (e.g.: changing a lot of "musts" to "would be encouraged to" and exempting the court's programs from control by LEAA) in the hopes of alleviating the court's hesitation towards the use of LEAA funds for needed improvements.

4. Other Problems

One of the major barriers to acquisition might be differences in value systems as to what constitutes a desirable innovation. Especially as regards innovative programs, the same program may be viewed by one sector as "coddling criminals" and by another as "cruel and unusual punishment". For example, in some parts of the U.S., the concept of indeterminate sentencing (e.g.: 10 to 20 years), a California innovation, is now being viewed as more punishing than a flat-time sentence (e.g.: 18 years) with time off for good behavior (thus, a sentence could be only 9 years actual time).

Perhaps a major stumbling block to the acquisition process is the fact that nearly all criminal justice agencies are under the auspices of a unit of government, and consequently do not have direct control over their purchasing processes. Rather, they must either get approval to acquire through the initial budget process (having an item listed in their appropriation) or they must obtain a special appropriation for that purpose. As we have indicated, the level of sophistication among user agencies is generally not high. However, it is usually much less among the non-criminal justice government employees responsible for the flow of funds. Consequently, although a police agency may feel that an innovation would be of great assistance to its operation, the purchasing department, city council or budget director might substitute items (thinking that the need can be met at lower cost).

The bidding process often reduces rather than encourages innovations. Vehicle manufacturers may attempt to produce a vehicle in their line for law enforcement use. This vehicle is modified to increase safety in high speed pursuit, yet the bidding process may frequently eliminate such vehicles due to additional cost for the modifications. Unless the users can convince the purchasing department that it is necessary, the innovative vehicle is unlikely to be the one selected.

XVI. IMPLEMENTATION/UTILIZATION

Ideally, the potential problems of this stage of the R/D&I process have been considered all along the way. The capabilities of the user (who could in some cases also be the developer) to implement and utilize the innovation could affect research, development, marketing and acquisition decisions. Although successful business concerns would be unlikely to engage themselves in the creation of innovations that are far too sophisticated for the intended users, government supported R/D&I systems may engage in this activity in the hopes of providing leadership to improve the technical competence of the users.

In the criminal justice sector, the type of innovaton which requires sophisticated technical skills (Wilson & McLaren 1972) may be a new communications system or an operations research application to patrol scheduling (e.g.: randomizing the time when an area is patroled). These innovations may require a structured implementation plan, perhaps using implementation technology such as PERT (Program Evaluation and Review Technique). Activities involving both producers and users may include: hiring new staff, training, designing and acquiring supplies and forms, perhaps some organizational development interventions to overcome resistance to change, preparation of facilities, actual installation, testing and debugging, trial run and finally, monitoring, evaluation, feedback and modification. The end of this stage may be marked by a formal acceptance of the innovation on the part of the user.

An innovation about a new sophisticated (in a behavioral science manner) method of working with juveniles or adult offenders (such as the application of behavior modification techniques) may require the same type of training and careful planning to be properly implemented.

1. Approaches to Implementation/Utilization

Four strategies are primarily used to encourage the use of criminal justice innovations (Yin 1976):

1) Specific innovation -- the promotion of special specific projects through selective funding of grants.

2) Using intermediary institutions such as the police foundation and the Vera Institute to promote implementation and utilization by users who have a positive relationship with these institutions.

3) User agency R&D units -- concerned with immediate problems. These units are short-term in their orientation, but since they are responding to agency identified needs, use of research findings is not uncommon.

4) Dissemination of written materials to users regarding R/D&I findings. However, "all of the traditional strategies appear to have some serious shortcomings and may not hold great promise for the future. One reason for the difficulties may be that the traditional strategies have been aimed at the wrong target group -- i.e., the local service practitioner agency . . . they may be more effectively applied if addressed to other institutions that . . . have a potent influence over the work of local service agencies."

Possible alternative points of entry, those with "potent influence", include institutions concerned with training, certification, development of new legislation, professional activities and the organizational function of the local bureaucracy. More specifically (Yin 1976):

1) training: police academies, law schools and other basic (and often mandated by law) training programs that reach candidate practitioners;

2) certification: both initial and promotional exams -- civil service or other;

3) new legislation: making legislators aware of innovations in the field;

4) professional activities: using professional associations to disseminate R/D&I information to users; and

5) organizational functions: assuring that R/D&I information is received by the organizational decision makers (e.g.: the individual who decides what equipment to buy).

Some significant implications to these alternative strategies have been postulated. For example, Yin (1976) lists:

> "...a less direct link between a specific research project and a specific change in criminal justice practice."
>
> "...there will be a much longer time lag between the R&D activity and the eventual installation of new practices."

> "...R&D utilization strategies will be aimed at different target audiences."
>
> "the use of natural entry points does not preclude continued use of certain traditional utilization activities."

These implications when coupled with the components of the institutional analytical process -- barriers due to a lack of R&D history, weak bonds between elements in the R&D user system, weak bonds between the R&D institutions and users, and statutory limits on R&D institutions' roles and responsibilities -- may be the reason for continued use of traditional strategies in the criminal justice system (Rettig 1976).

NIMH's Center for Studies of Crime and Delinquency uses two approaches to obtain utilization of R&D results -- an information program disseminating monographs and reports on both topics and issues; and a research utilization strategy specifically developed for selected projects. NILECJ's approach is similar. "The underlying logic within NILECJ for research utilization is to systematically package the results for the research program and disseminate them widely to the criminal justice community" (Rettig 1976). Three approaches are used to accomplish this: the National Criminal Justice Reference Service, (an international clearinghouse for researchers and practitioners with over 30,000 subscribers); exemplary projects; and prescriptive packages. Additionally, NILECJ's Office of Technology Transfer provides short training programs on a limited basis for programs of special interest. While the OTT is building considerable redundancy in the communication channels to prospective users, "given the complexity of institutional relations in the criminal justice policy system, the establishment of communication channels and networks is itself of great potential importance" (Rettig 1976).

2. Implementation/Utilization Issues

Establishing a new community corrections program may require site selection, hiring and training staff, new forms, new procedures, selection of participants and the skills required to gain the support of key persons such as the local police, neighbors and perhaps the court. The skills to accomplish the latter may be just as scarce as the technical skills discussed previously. Another program may require community organization skills to implement (LEAA's Community Anti-Crime Program). Implementation problems may be great barriers to innovations in the area of equipment or sophisticated systems. These difficulties may prevent the producer from ever getting involved in this sector. Regarding innovative programs, often little consideration is given to implementation problems; and the time necessary to get a new program running is often underestimated for this reason. Utilization can become a problem, especially if support is withdrawn after the implementation process.

In criminal justice, there is often a great deal of enthusiasm attendant with an innovation, bringing along a great deal of support both internal and external. The user agency may be particularly responsive to the implementing staff; but once the newness is over, this responsiveness may disappear, along with the handpicked staff which performed the implementation pilot test. Sustaining support may be lacking both internally and from the producer. Unless specific mechanisms are set up, diffusion within the user system may not occur, inhibited by jealousy or poor communication.

The large urban elements of the criminal justice sector have less problems with implementation and utilization since they are likely to have specialized staff to be involved on a full time basis. They may also have a much closer relationship with the producing institution. The producing institution may be willing to invest more effort in the implementation of a large system since the sale will be larger and follow-on benefits are likely if the large agency is considered a leader by the smaller agencies. LEAA and the sub-agencies created by the enabling legislation (state criminal justice planning agencies) will fund agencies to allow them to purchase implementation support. They also provide some direct technical assistance. When preparing instructions and manuals for new programs, the need for language which will reduce implementation problems is taken into consideration (specific step by step instructions and check lists may facilitate implementation). LEAA encourages close association of users with the "producer" in a situation of trying to encourage the dissemination of an exemplary program (for example, the Vera Institute's bail program or the Des Moines Community Corrections Project).

XVII. SUPPORT SERVICES

Research/Development and Innovation systems require support from institutions outside of the system or marginally within the system. Such research support service include: research libraries, suppliers and maintainers of: laboratory equipment, computers, office equipment, automobiles, weapons, etc. R/D&I system institutions must decide whether or not to develop the needed capability within the system or to acquire it from an outside support service. The criminal justice Research/Development and Innovation system relies extensively on institutions outside of the system or those which span several sectors. Many criminal justice sector innovations involve technology transfers across sectors. Sometimes these attempts fail when inadequate attention is given to the unique aspects of the criminal justice sector.

1. Problems

Various programs attempted under the NILECJ Equipment Systems Improvement Program failed to bring institutions from other sectors into the program (Radnor 1975). In many of the R/D&I system functions, the institutions are involved only on the fringe of the criminal justice sector, with most of their work being done in other sectors. Weapons may be principally designed for defense, with law enforcement being a secondary market. The lack of qualified consultants in the area of implementation in law enforcement is a major weakness of the system (Radnor 1975). Many universities play roles (e.g.: Northwestern University's Traffic Institute in training). LEAA has played a major role in invloving external institutions in the criminal justice R/D&I system by providing the funding and serving as a linking mechanism to encourage the participation of these sector spanning agencies. There has been some notable success in this area. Motorola has developed a line of equipment expressly for criminal justice communications.

Finally, a great reliance on the public sector exists since the failure of the criminal justice system has a significant negative effect on citizens as more of them become victims of crime. Consequently there is a major effort to involve private citizens in the R/D&I process.

2. Other Issues

The above are by no means exhaustive, merely reflecting some of the needs of the process and activities of the R/D&I area. For example, Daniel Bell (Bell 1976) categorizes task which would provide opportunities for a greater degree of public participation. This in turn is perceived as a useful means of addressing critical issues in the area, since these task forces would represent constituencies which are not found in the established criminal justice R/D&I network (advisory bodies; fact finding bodies; public relations groups; policy recommendation groups). Such groups would provide relevant input into the foci of R/D&I activities.

In the area of personnel selection/recruitment/training, external agencies and private organizations can assist in the search for qualified staff. University groups or external advisory bodies can provide services in reviewing new proposals (peer review). Nongovernmental agencies/individuals serve as technical consultants.

In the case of particular research projects which involve human subjects, review boards (e.g.: of universities) provide services in terms of ensuring that proper procedures have been followed in obtaining informed consent of participants. Such boards judge compliance with established national guidelines.

Communication mechanisms to involve these types of external groups are essential to the adequate functioning of the R/D&I activities of the criminal justice sector.

XVIII. EVALUATION RESEARCH

The phrase evaluation research implies evaluation conducted in such a way as to expand the knowledge base. A single function in the R/D&I process may be evaluated as may the entire process, and evaluation as a specific activity is vital in several functions of the process. In the research generation stage, evaluation is made by tests of the innovation. In the development stage, evaluation is made of the revised product. In the marketing stage, the evaluations gained from the prior tests and demonstrations are important data to utilize in the promotion of the innovation. The user evaluates the effectiveness and and efficiency of the innovation, while the researcher or lead federal agency may wish to evaluate the entire R/D&I process.

1. Problems

In the criminal justice sector, evaluation has generally been neglected. With the advent of federal funding in the late 1960s and the evaluation required by the enabling legislation, this function received more attention. The implementation of criminal justice was impeded by difficulties which plauged social programs in many sectors. One problem, which frequently occurred in the evaluation of federally funded innovations, was that the grantees often did not concern themselves with the issue of evaluation until it became time to request continuation funding. Thus evaluation people were not involved until just before the end of the program. At that point it was virtually impossible to conduct a good evaluation, since inevitably the data needed had not been collected. Another problem emerged in the cases where evaluators were brought in early in the process. Here, the desire of the evaluators to "help" causes two difficulties. One is the well known issue of the evaluator being coopted into given a favorable report on what the program looks like now that he has redesigned it. The other less discussed point is that the program person may not feel free to disregard the evaluator's suggestion for fear of incurring his anger or at least an "I told you so" posture towards the program, particularly when refunding is an issue. Even evaluators with great integrity have not always been able to resist the temptation ot interpret the results in such a way as to accentuate a failure which, in the evaluator's opinion, might not have occurred if the program people had listened to the evaluator. One way around this difficulty may be to use different evaluators for formative than for summative evaluation. There has been an attitude in some areas of criminal justice that impact evaluation is not needed ("We know what needs to be done") and only process evaluation is desired (finding out if the program has been implemented correctly).

The Task Force on Criminal Justice R/D&I report identifies specific problems with criminal justice evaluation such as: methodological deficiencies, failure to collect process information, failure to use control groups, failure to plan for evaluation and failure to disseminate evaluation results (TFCJR&D, 1976).

2. Meaning

There also seems to be some confusion about the meaning of various terms associated with evaluation such as: evaluation, evaluation research, monitoring, and research. There are statements in LEAA documents that evaluation of demonstration does not need to be as rigorous as evaluation of a test. Such statements imply different types of evaluation for different functions in the R/D&I system.

What evaluation takes place in the ciminal justice system is funded by or sometimes performed by LEAA, either the Office of Evaluation in NILECJ or the program offices in the Office of Criminal Justice Programs. The evaluation staff in the Office of Planning and Management develops the LEAA evaluation plan which identifies the programs to be evaluated during the upcoming planning period.

3. Criteria

An overarching difficulty which pervades the entire criminal justice sector (not only the R/D&I system) is the issue of which criteria to use for evaluation. LEAA itself is caught up in a debate between advocates of a criteria of reduction of crime and of improving the criminal justice system (Blumstein 1965). Fuzzy criteria such as aid in improving the ysytem are virtually unevaluatable. This difficulty is often resolved by lowering the level of the evaluation to some process criteria such as grants made or programs initiated.

Upgrading evaluation to include such impact criteria as reduction of crime is fraught with political risks. It has to be recognized that crime is influenced by so many other variables that crime reduction may be an inappropriate measure of effectiveness. This position, however, could be fatal to an agency which is expected by Congress and the public to "reduce crime".

Among the evaluative factors or measurement tools that could be used in the criminal justice sector are the following (TFCJR&D 1976):

- Change in the number of crimes in the area in which technology is used;
- change in economic loss resulting from crime;
- change in the number of deaths and personal injuries resulting from crimes
- change in psychological harm.

- change in the number of suspects arrested or convicted;
- more or less efficient use of manpower;
- change in equipment reliability and/or ease of use; and
- change in the level of citizen fear of crime.

However even these factors have basic and inherent weaknesses as evaluation criteria. For example, in the evaluation of a crime prevention program, it may be noted that there has been a significant reduction of the targeted crimes within the area that the program operates. Further analysis may well demonstrate that there has been no overall reduction of crime, but rather "geographical displacement" -- that is the moving of crime from the jurisdiction in which the program operates to a neighboring jurisdiction without such a program. Consequently the question of whether there would have been a crime reduction if the program were comprehensively applied in all jurisdictions remains unanswered.

4. Standards

There are significant gaps in standards needed for criminal justice evaluation. Existing evaluation research tends to emphasize evaluation of technology or laboratory evaluation, and the development of ideal performance standards for existing technology (TFCR&D, 1976). The evaluations do not tell whether products already in use meet established standards. Furthermore, the standards that are developed often do not reflect the differing needs among agencies. For example, standards regarding communications equipment may eliminate equipment that would not be effective in hilly country. Yet for law enforcement agencies in the plains states, a purchase of "below standard" equipment (at less cost) may achieve the required level of equipment effectiveness, since there is no hilly country within the user agency's jurisdiction.

In one sense evaluation completes the R/D&I process as the final activity. In another sense evaluation may be a beginning as it triggers the process to search for a better innovation and provides the feedback loop to a new innovation cycle.

XIX. RESEARCH ON R/D&I

1. Current Situation

In the criminal justice sector, research on the R/D&I system has primarily taken the form of distillations of expert anslysis and opinion. There "review of the situation" type reports (Twentieth Century Fund Task Force 1976 & National Academy of Science 1977) have been based on interviews, site visits, archival records, and discussions among panels of scholars. Like the Report of the Task Force on Criminal Justice Research and Development these reports contain prescriptive recommendations. The NAS study of NILECJ (National Academy of Science 1977) is directly R/D&I related, and is again more descriptive and prescriptive than analytical.

Recently, there have been specific studies on aspects of the R/D&I system such as the Lazar Institute's External Review Mechanisms (Lazar 1976). These also follow the above format of description and prescription.

Finally there have been few actual research studies on aspects of R/D&I. One was conducted by Northwestern University's Center for the Interdisciplinary Study of Science and Technology (CISST) on the Equipment Systems Improvement Program of NILECJ (Radnor 1975). This study was university based and analyzed the nature of the R/D&I system as it related to criminal justice equipment. This study analyzed the entire process for need identification through possible commercialization of innovations, discussing each step of the process.

2. Problems

One of the impediments to analytical research on R/D&I in this sector is the lack of uniform definitions among the various R/D&I projects. The absence of a common terminology makes comparative analysis difficult at best, and leads to the descriptive/prescriptive research identified above. A factor that contributes to this impediment is that R/D&I in criminal justice is performed by a wide variety of sectors other than criminal justice. As the section on the personnel base points out, the rapid growth of funding for criminal justice R/D&I has resulted in an equally rapid growth of the number of disciplines with "something to offer."

Another impediment may well be the disparity in user groups. As pointed out in the preceding sections, user group may well range from schools (for prevention programs) to corrections (for rehabilitation programs). This lack of a singular "mission" that is agreed upon even within the criminal justice system itself, much less by the tangential systems such as schools, social welfare agencies, economics, etc., makes it difficult for prospective researchers of criminal justice R/D&I to gain encouragement.

The above leads to the conclusion that research of criminal justice R/D&I has not been a priority within the system. This may be for a number of reasons in addition to those above.

Research on R/D&I is a new field while the concept of R/D&I itself has only recently gained acceptance, and that on a limited basis, within criminal justice. Users and funders (in a system primarily oriented towards problem-focused research) tend to see research on R/D&I as seeking knowledge for knowledge sake, rather than as a means of improving the utility of the R/D&I being performed. Users particularly see research without a readily applicable result as a waste of funding when they consider themselves short-staffed, and that their needs could well be satisfied with existing technology. A police chief using communications equipment purchased in the 1940s who depends on a "frugal" city council for appropriations, may be well satisfied with equipment representative of technology of the 1960s, and may want funds used to buy that, rather than spent on further development of innovations.

Still, there has been a recent trend towards research on R/D&I, indicated among other things by the recent task force study (TFCJR&D), by Rettig (1976), the NAS (1976) study, Radnor (1975) and the very existence of this document. As the R/D&I concept gains increased acceptance within the field, research on R/D&I may benefit and gradually become more analytical and sophisticated. As a contribution to this cause we have developed, and attach, a rather more extensive bibliography on source materials than any we were able to discover in our research for the preparation of this review.

CHAPTER SEVEN

AN ILLUSTRATIVE CROSS-SECTORAL COMPARATIVE CONTEXTUAL ANALYSIS

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CHAPTER SEVEN

AN ILLUSTRATIVE CROSS-SECTORAL COMPARATIVE CONTEXTUAL ANALYSIS

In the previous four chapters, we have illustrated how the CISST contextual analysis framework may be used to describe the overall context for R/D&I in four sectors: education, civilian aviation, health and criminal justice.

While a full cross-sectoral comparison would be beyond the intended scope of this report, there is merit in providing here some insight into the process and utility of cross-sectoral comparative analysis beyond that which the reader could glean from separate readings of Chapters Three through Six. Thus we have chosen to present here (in a table format) a comparative summary of these four contextual analyses. The more detailed discussions in Chapters Three through Six should facilitate understanding of the brief summary context descriptions provided in this chapter.

This chapter, then, should provide some insight into the similarities and differences between sectors -- and by so doing, provide some insight into the process and utility of comparative contextual analysis of R/D&I.

1. Environments of the R/D&I System

	Health	**Criminal Justice**	**Civilian Aviation**	**Education**
Political	AMA lobby AHA lobby High level of support Spirit FDA regulation	Sensitive to environment Responds to political environment Federal primary funding source Congress and Executive decision making on R&D	Heavy federal support FAA and Dot roles Regulated industry International Prestige Recent Congressional suspicion of industry	Vulnerability, open to pressure Education operating system paid for with public funds under local, lay control; therefore, local influence on acquisition/utilization Subject to scrutiny and debate Decentralization (in US) Lack of congressional confidence in R&D
Level of Support	Very high	Medium high	High	Weak
Level of Demands	Heavy	High	Medium	Needs high; demand for products or materials high, but not necessarily high for external R/D&I
Credibility/ Status	High	Low	High	Low
Social	Ready consumer market Malpractice suits Concern for ethics Better informed patients (Health is value laden)	Sensitive to environment--public reacts to some innovations	Growing demand - may be flattening Environmental and safety concerns	Vulnerable, open to pressure Low legitimacy of professional expertise (Education is value laden)

1. Environments of the R/D&I System (Continued)

	Health	Criminal Justice	Civilian Aviation	Education
Economic	Large and growing amounts of funding (mostly federal) Health Services: Relatively stable Oligopoly with inelastic demand Lack of price sensitivity -- third party payments Very profitable Rapidly growing phase of federal R&D budget	Lack of funds in sector Companies won't invest NILECJ (LEAA) funds -- stable for 10 years	Feast and famine Substantial federal funding Oligopolistic airlines and manufacturers Fuel Price Squeeze Major export markets Very big market Technology as a marketable commodity	Lack of funds Comapnies won't invest Reductions Voters defeat school budgets and bond and tax issues Effects of recession
Science and Technology	Rapid rate of change Relatively understood Biological and physical science High specialization	Uneven rate of change Low reliability Uncertain Weak Social science base Low specialization	Rapid rate of change Well understood Documented physical science based, some biological and social High specialization Cumulative, incremental Few radical Technology transfer very important (from military) Diverging needs Market responsive Technological imperative	

2. Historical Development

	Health	Criminal Justice	Civilian Aviation	Education
Degree or phase	Mature	Introductory, especially at local level (rudimentary)	Highly mature, large scale	Introductory
Age	Up to 1940 Introductory 1940-45 Transitional 1945 Maturity	(Recent)	Up to 1913 Pre-birth 1914-39 Introductory 1940-50 Transitional 1950's Maturity	Up to 1964 Pre-birth 1960's Introductory Approximately 10 years for large scale external R&D Sector is old
Legitimacy	Few question the value	(Not established)	R&D has the major role High public acceptance of R&D products	Low Not yet established Values are anti-external R&D
Articulation/ Evaluation	Disease to health Now hospital/drug/ physician Now NIH based Highly specialized but diverse	Poorly delineated	Specialized large companies, NASA, etc. Well defined responsibilities	Unstable funding/personnel base Inadequate knowledge base, standards, information flow. Poor KP-KU integration Lacks many functional specialties
Effectiveness	Very	Low	Very	Generally weak/mixed quality outputs

2. Historical Development (Continued)

	Health	Criminal Justice	Civilian Aviation	Education
Critical events	1930 NIH 1935 Title VI Social Security Act 1937 National Cancer Institute 1941 Committee on Medical Risk WWII successes 1944 Public Health Service Act 1945-55 Major funding increases Late 1900's War on Cancer	1968 Omobus Crime bill - NILECJ	1915 NACA WWI WWII 1958 NASA, FAA Korean War 1960's Space Race 1966 DOT 1970 SST 1971 Non-orbiting R&D Support	Mid-to-late 1950's Federal government sponsors research/curriculum development Major expansion of funding 1960's 1954 Cooperative Research Act 1958 National Defense Education Act 1960's Elementary and Secondary Education Act and amendments to Cooperative Research Act creates network of R/D&I institutions; later some labs and centers are dropped 1972 NIE established

3. Institutional Base (Network of Institutions)

	Health	Criminal Justice	Civilian Aviation	Education
Specialization	Universities (medical schools) Federal research institutes Hospitals (medical schools) (private/public) Industry Diversity Fairly large	Diversity Social/Procedural in 200 universities, agencies, etc.	Extensive university/NASA manufacturing/airlines subcontracting Down to department levels FAA, DOT, CAB	Less functional specialization than in many other sectors Variable
Number of Institutions	Fairly Small	Hardware-few Software-many	Few Basic (NASA and DOD) Manufacturing (plus subcontractors) Airlines Oversight	Large number of institutions carrying out R/D&I; relative small number specialized in educational R/D&I
Clusters	Not very linear	Diffused	Linear Parallelism	Looped and adjacent, parallelism Applied research variously clustered with dissemination, with evaluation, and/or with implementation/utilization
Gaps	No Major	Major (Need identification)	None	Major
Redundancy	Some Overlap		Little	Very high

3. Institutional Base (Network of Institutions) (Continued)

	Health	Criminal Justice	Civilian Aviation	Education
Types of Institution	High quality Federal labs Also university based	Business companies Federal labs Universities Private research Foundations C. J. Agencies	Large Formalized	A set of three parallel substreams: 1) Colleges and universities 2) Quasi-public and private sector institutions 3) SEAs, ISAs, LEAs
Cooperation		Weak	Common (joint ventures)	Little - some developing
Linkage	Fairly Strong	Weak		Inadequate Diffuse Lacks formalization and coordination Increased efforts towards linkage

4. Goals, Policies, Strategies

Health

Create knowledge
Techniques and products
Effectiveness rather than cost criteria
Most users are the health care practioners -- convince them
Emphasis has been on curing rather than preventing disease
Influence of external strong
Death vs. other problems
Congressmen are influential

Criminal Justice

Unclear goals of C.J. sector
Diversity of priorities
Disagreement on value of equipment and systems vs. social issues
Competition for resources
Role of NILECJ
Producer of R&D goals

Civilian Aviation

Economy, maintenance, noise, pollution, speed, range vs. military performance, payload
NASA/producers/users spectrum
Time horizons shorter operations
Costs go up
Increasing role of R&D
Clear specialization
External environmental effects
  Energy
  Environmental impact
  Costs

Education

Weak goal setting
Federal policy goals -- improve education practice and knowledge
In practice
Discontinuous shifting priorities
Inconsistency
Lack of intermediate goals
Lack of mechanisms to develop goal consensus
1950's and 60's goals set by educational research community
Mid 60's -- central programmatic R&D
Short time horizon
Externally defined
Emphasis on development, packageable products
Build regional labs
NIE increased emphasis on improving practice, dissemination, implementation, utilization building user capabilities

5. Administrative Processes

Health	Criminal Justice	Civilian Aviation	Education
Dual career paths -- administrative/professional Funding process generating needs for greater control; therefore, larger proportion of administration Health planning becoming recognized specialty Projects relatively small, lessening applicability of OR/MS techniques such as PERT	General/research/development Sophistication of administration varies Production/marketing/distribution varies with organization Acquisition/implementation/utilization/evaluation Less variability Generally lower level of sophistication Barrier to adoption	Large number of methods specifically for aerospace R&D Success may be context related	Has not been area of major concentration

6. Personnel Base

Health	Criminal Justice	Civilian Aviation	Education
R&D	User Organizations	R&D	R&D
Personnel in research located throughout R/D&I system Large proportion professionals Professionalism found at KP and KU ends of R/D&I process	Labor intensive Personnel is obstacle to innovation adoption Greater specialization can lead to greater adoption rates	Large numbers of science and engineering and other highly developed skills Skill mix and concentration critical High rate of obsolescence of skills Research labor levels fluctuate with economic condition Mobility high within sector	Small overall base Concentrated in research, development and evaluation Inadequate in dissemination and implementation/utilization Research orientation derived from academic project research rather than program development Inadequate supply of R&D managers

7. Funding

Health

Sponsorship (1973)
- -Federal - 60%
- -Industry - 30%
- -Foundations - 5%
- -Voluntary health agencies - 5%

3.5 billion

Federal funding dominant in basic and clinical research

Medical profession dominates the influence on allocations

Criminal Justice

Budget levels and processes impede adoption (budget primarily labor-intensive)

Private funds not encouraged by perceived characteristics of the market

Federal government dominant source of R&D funds

Civilian Aviation

1958-1968

Federal - 5 billion a year

Private - ½ to 1 billion

Long time span from research to $ return

Education

Federal government primary sponsor

4 weaknesses:
- -concentration of sponsorship
- -amount of $
- -diffusion of expenditures over broad spectrum of projects
- -instability

Smaller percent of Gross National Product than other sectors

8. Information Flow

Health

Open-free-extensive
Problem: overload

Criminal Justice

Lateral transfer at user and research levels
Less from research to user
User organizations - informal
Periodicals

Civilian Aviation

Research level free and easy
Development/production is proprietary

Education

3 information systems
- R&D -->R&D
- user --> user
- external R&D --> user

All weak and insufficient
Media
Annual meetings
Publications
Not enough informal nets
Each system has barriers
No policy or interventions directed at info-transfer improvement

9. Innovations

Health	Criminal Justice	Civilian Aviation	Education
Trend towards increasing costs. Varies from simple to highly complex However, the more technologically complex the innovation, the more likely is adoption (in larger hospitals)	Moderate number	Visible innovations tend to come in very large costly products but there are also many hidden incremental improvements to existing equipment and support systems	Products that go through a formal process of development have high development costs; less expensive for practice based development "People-change" products - implication for implementation (product/user reactiveness)

10. Need Identification

Health

- Need for research is a constant need
- Potentials stressed more than needs
- Not-for-profit exploration in developing new treatments
- For-profit firms concentrate on greatest consumer use
- Process for need identification is surveying the providers of health care and noting characteristics of consumers.
- Emphasis on effectiveness more than on efficiency.

Criminal Justice

- Anyone can
- Not performed uniformly by users
- Both product availability and problems affect process
- But self-evaluation by departments is weak
- External pressures often spark needs
- Little market research (except 2-way communication)
- Outsiders find it hard to need identification -- don't understand C. J. operations

Civilian Aviation

- Producers stimulate user needs (as well as need identification)
- Airlines stimulate consumers
- Aircraft close contact ultimate public

Education

- Weak
- Mostly episodic, tuned to funding
- Scattered throughout R/D&I
- Lacks formalization
- Intuition
- Opportunistic
- Little data-based, but increasing
- Very little translation into specific R/D&I requirements
- Vague statements
- Unable to create integrated KP/KU perspectives

11. Generation/Research

Health	Criminal Justice	Civilian Aviation	Education
Biological science but also physical sciences coming in and social sciences Total system of health (holistic) Lab and field (increasingly) High technology equipment Lack of integration across segments of the field; variety of settings; usually animals	Great variety of technologies Problems with Technology transfer widely dispersed Federally funded labs Very little role for university	Science based Fundamental Physical sciences (University), NASA, DOD Laboratory and field research Large scale facilities Teams (large) Accumulation of detailed advances Fast publication Mission oriented Excellent research Environment Product and program matrix organization Research stops at prototype stage.	Relatively small amount of education practice is based on research; is rather more intuitive Poor definitions of questions Low rigor; inadequate grounding in theory Methodology issues Problems: Cooperation between disciplines Determination of priorities receives relatively little support Ethical issues Control of research autonomy Mostly field research Research moving out of university

12. Development

Health	Criminal Justice	Civilian Aviation	Education
Done on human patient Side effects Done in hospitals Welfare patients Pilot testing	Difficulties in commercialization impede development Important potential role of small producers	Most complex High cost Prototype Critical stage Not always clear output Complex multi-department process Ends with flight testing High technology transfer from military Cultural aspect	(a) Use the engineering model in formally defined development (b) But lot of informal (c) Follows formal sequential steps to field Large scale, expensive projects Much practice-based development; not rigorous development model; little field testing; little systematic evaluation; often not packaged for generalized usability; less expensive

13. Production

Health	Criminal Justice	Civilian Aviation	Education
Production considered as: 1) manufacturing supplies & equipment and, 2) providing services directly to consumer Quality primary concern of production - more than cost or price Several sources of quality standards and evaluation: 1) FDA 2) Professional standards Review Boards 3) American Hospital Association	Producers generally cautious about making commitment to C. J. especially for innovations Very few production standards or specifications for most product areas Most producers of C. J. innovations are in C. J. as a secondary market	Production is in custom-shop environment Production control is customer oriented in design adaptation, delivery, etc. Long lead times involved in production scheduling Production of major product (airplanes) involves one prime producer & many subcontractors for subassemblies and subunits Quality control of central interest Complicated by complexity of production and assembly processes	Most producers of education products are not primarily education oriented (similar to L.E.) Production not a major issue area in education Production capabilities (printing, etc.) readily available

14. Marketing/Distribution/Dissemination/Diffusion

Health

Health industry has experienced growth, no prospects for short-range drops in growth rate.

Increased risk-avoidance may put greater pressure on prepurchase testing and evaluation

Changes in goal-orientation of medical practice from corrective to preventive feeds back to producers in form of new needs and requirements and possibly, in marketing strategy

Drug marketing relies on personal contact with physicians by "detail user"

User almost exclusively dependent on producer for information

Producer provides both the information content and the information dissemination function

Large hospitals are the innovations and early adopters

Criminal Justice

Market highly fragmented in size variability and goal orientation of users

Fragmentation impedes entrance of new producers into the market

Producers do not (generally) find it economically feasible to sell exclusively to C. J.

Many different distribution channels exist

Differences are often product-specific

Information passed on informally, especially from large to small users

Process not well institutionalized

Requires considerable initiative on part of small users

Diffuse purchasing process presents formidable complicating picture to potential suppliers

Labor intensive-very small percentage of user budget goes to innovations

Civilian Aviation

Market as a whole, characterized by growth

Users relatively sophisticated customers

Individual users highly variable in adoption behavior in timing, creating fluctuations

Market needs segmented creating hanging needs for innovative products

Close customer contact by producer sales personnel required to generate interest and commitment to justify production of innovative products.

User commitment must precede investment in production

Innovation adoption aided by ability to dispose of functional current products with after-market

Education

Function includes: dissemination/diffusion, marketing, distribution

Overall impact on system: weak

All receiving current interest by sector planners and policy makers

Dissemination activity shifted from transferring of bodies of knowledge (research results) to information about packages products or developed practices.

Information dissemination aided by ERIC for researcher; less helpful for practitioner

Federal funding supported organizations directly involved in information dissemination

Current NIE interest in dissemination aimed at up-grading user adoption behavior. Strategy is: proactive, interpersonal, user-oriented, field-based network

14. Marketing/Distribution/Dissemination/Diffusion (Continued)

Health	Civilian Aviation	Education
Market characteristics for diffusion of innovative equipment is not well understood	Political and economic environment of the sector important factors in the adoption process	Distribution system undeveloped

15. Acquisition

Health

Concentrates on hospitals in acquiring new technologies

4 factors affecting acquisition decision
1) needs of local population
2) present services structure
3) status
4) availability of funds

Status a major factor

Funding generally available-controlled by state planning agencies

Large hospitals are the innovators

Little is known about the adoption decision process in the hospital

Standards for equipment are well articulated and regulated

Increased risk-avoidance by purchasers (hospitals and physicians) will emphasize pre-purchase test and evaluation

Criminal Justice

Activities included:
1) pre-purchase evaluation
2) testing
3) selection of specific product
4) purchase decision

User agencies lack resources and technical capabilities for pre-purchase testing and evaluation

Specialization of function (e.g.: communications) tends to improve evaluation

Standards are generally lacking

where they exist, they make evaluation more effective (e.g.: communications)

Purchasing tied to bidding thereby requiring standards for specifications

Bidding also places great emphesis on price or cost

The purchase decision is based more on administrative and financial factors than technical

Purchasing also complicated by being integrated with purchasing function of other governmental agencies, such as fire, street, etc.

Funds are a major problem

Civilian Aviation

Search for innovations (new airplanes) is well articulated function-held to be a critical function

Pre-purchase evaluation and testing well established as process activities

New aircraft adapted for both
1) optimal fit with present operations
2) develop competitive edge as "launching purchaser"

Sophisticated buyers

Cost of new airplanes and systemic effects of adoption are forcing process to be even more critical and analytical

Education

Acquisition functions virtually non-existent as institutionalized activity - not an articulated and assigned responsibility

No systematic link between suppliers and potential users

Very little evaluative information regarding available products

Quality control not well exercised

Standards generally lacking

"Potential targets" for acquisition decisions must be better defined-teacher, principal, curriculum specialist, superintendent, or community interest groups

Some evidence suggests linkage to external resource systems are important factors

NIE proaction -
1) Consumer information unit
2) R&D utilization unit
3) Development of catalogs of available products; funding programs to provide evaluation information
4) Funding organizational development and other projects to upgrade user ability to adopt innovations

16. Implementation and Utilization

Health

Highly skilled user population

Professional vs. administrative staffs affect implementation

Differentiated adoption characteristics of large vs. small user organizations (hospitals)

Criminal Justice

User problem low level of technological sophistication

Producer assistance minimal-too risky, given low potential for sales.

Civilian Aviation

Implementation has effects throughout the user system and in all phases of the organization

Barriers:
- customer acceptance
- political/legal constraint
- user structural or technological barriers
- cost

Education

One of most neglected functions in educational R/D&I

Discrepancy between adoption rate and use of innovations

Caused by:
1) User norms and resistance
2) Lack of technological sophistication necessary to implement

More known about 1 than 2

Linkage organizations have evolved - helping educational organizations become more adaptive

17. Support Services

Health	Criminal Justice	Civilian Aviation	Education
Almost always available Not cost-sensitive Support services are concentrated within the sector itself (in hospitals, research, pharmaceutical companies, equipment suppliers). Very little other support from sources external to these groups	General sources: Federal agencies C. J. professional associations Outside consultants Need ID: some by users -- more by producers Generation/Research/Development some efforts of direct subsidy from Federal agency to encourage entry of new firm Production Most producers are support oriented Marketing/Distribution IACP supports by "equipment listing" distributions; support is passive. Implementation and Utilization Relatively unsupported university institutes support manpower development Evaluation C. J. associations support development of standards Outside consultants directly evaluate or up-grade in-house evaluation	Some support functions: -sub-contracting for components, equipment, and urgent services No information on extent to which these organizations are in or out of the aerospace sector	Equipment service organizations Printing and publishing organizations Survey research organizations Relatively little published literature about support functions

18. Evaluation Research

Health	Criminal Justice	Civilian Aviation	Education
Evaluation criteria effectiveness-oriented rather than cost or efficiency oriented Evaluation standards vary at different stages of the R/D&I process	Evaluation not a prime characteristic of users Lack of standards and skill level of user personnel prevent development of evaluation as an effective function.	Equipment evaluation methodology fully developed - high credibility, rigorous standards, substantial control by federal agency	Most rapid advance of all educational R/D&I function in last 10 years Federal funding demanded evaluation-generating specialization of evaluation Specialization takes place in private sector as well as academia Methodology one aspect of specialization Evaluation research knowledge becomes more sophisticated Evaluation research function has acquired increased political decision making influence; still not widespread as basis for decisions In spite of the development, evaluation research function still in growth phase Evaluation methods and credibility based essentially on social science methodology

19. Research on R/D&I

Health	Criminal Justice	Civilian Aviation	Education
Little or no research on health R/D&I Some descriptions of components but data are not comparable.	Very little - just beginning ESIP	No previous descriptions of overall R/D&I system Systems and techniques for management of R&D	Much analysis and research because: 1) Negative political climate 2) Self-consciousness of social sciences in 60's 3) International influence 4) Sponsors' interests in evaluation research for policy formation. Much literature but: 1) Directed at segments of the system 2) Relatively little empirical data 3) Atheoretical 4) Little used